VOLUME 8
1984



BIOGRAPHICAL MEMOIRS OF FELLOWS OF THE INDIAN NATIONAL SCIENCE ACADEMY



INDIAN
NATIONAL
SCIENCE
ACADEMY
Bahadur Shah
Zafar Marg
New Delhi

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Volume 8

1984

INDIAN NATIONAL SCIENCE ACADEMY
NEW DELHI

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This volume was first published in January 1984.

Price : **Rs. 75.00; $ 25.00**

Printed and published by A. K. Bose, Executive Secretary, Indian National Science Academy, Bahadur Shah Zafar Marg, New Delhi-110002, and printed at Kapoor Art Press, A38/3, Mayapuri, New Delhi-110064.

PREFACE

THE present volume, eighth in the series, includes biographical sketches of Fellows who had made pioneering contributions in diverse fields ranging from psychology to meteorology.

Prof. N. N. Sengupta was a pioneer psychologist of the country and the founder of the *Indian Journal of Psychology*. The blending of science and literature in him emanated from his lasting friendship with Rabindranath Tagore.

Prof. S. P. Agharkar was not only a plant taxonomist of repute but also a great organiser. Several institutions such as the Indian National Science Academy (formerly, National Institute of Sciences of India), the Department of Botany, University of Calcutta and the Maharashtra Association for the Cultivation of Science owe their development to his foresight and scientific leadership. He left an indelible stamp on Indian Botany. He was mainly instrumental in stopping the transfer of the herbarium sheets from the Indian Botanical Gardens, the then Royal Botanic Gardens, Calcutta to abroad and also for opening up the overseas scholarships of 1851 Exhibition, London to Indian scientists in the 1930s. Dr. Kalipada Biswas, almost a contemporary of Agharkar, was the first Indian Director of the Indian Botanical Gardens at Calcutta and his interest in and contributions to lower groups of plants led to a school of algological research in Calcutta. His voluminous and exhaustive contribution to Indian medicinal plants is a source of constant reference. In Prof. J. J. Chinoy, one finds an eminent plant physiologist. Energy requirement of crop plants, drought physiology and ascorbic acid metabolism are some of the areas of his specialisation. Equally well known was Prof. J. Venkateswarlu in the fields of plant embryology and cytogenetics. The Indian Botanical Society and the Andhra Pradesh Academy of Sciences owe a great deal to his leadership and contributions.

Many westerners had served Indian science with distinction and dignity. Thomas Sherlock Wheeler was one such Irish Chemist to serve in India for several years. He made significant contributions to the theory of liquids, organic chemistry, development of industrial processes and also to the education of chemists both at the University and Secondary School levels. His studies on the Baker-Venkataraman Transformation were exhaustive.

Prof. B. Chatterjee was an outstanding soil chemist who served with distinction the Indian Agricultural Research Institute and the Bengal Engineering College. A man of exeeptional skill and meticulous care, he was associated with several learned societies.

In Prof. Rajnath, we find a dedicated geologist who had contributed extensively to the Geology of India, in general and to the Jurassic Rocks of Kutch, in particular. He was the chief architect in the creation of the Department of Geology at the Banaras Hindu University. His interest ranged from the Indian *Jari* industry to the well-known Ayurvedic drug *Shilajit*.

Profs. Piare Lal Srivastava, S. Ghosh and C. T. Rajgopal were three eminent mathematicians. Prof. Srivastava specialised in the "Theory of Func-

tions." He was well known for his administrative and organising ability and was an educationist of a high order. He was responsible for the Kayastha Pathshala and the Chaudhary Mahadeo Degree College, affiliated to the Allahabad University. He served as the Vice-Chancellor of the Bihar University, Muzaffarpur from 1962 to 1965. Prof. Suddhodan Ghosh was a well-known mathematician and served the University of Calcutta for over a period of four decades. One cannot but admire his personal sense of ethics, when he sacrificed the post of Professorship at the Indian Institute of Technology, Kharagpur, just because of a casual promise he had given to one of his contemporaries who wanted to join the department. He specialised in fluid mechanics and elasticity. Dr. C. T. Rajagopal was a contemporary of the late Profs. T. Vijayaraghavan, G. H. Hardy and K. Ananda Rau. His contributions are well known in the areas of sequence, series, summability, functions of complex variables and history of Medieval Kerala Mathematics. He will be particularly remembered for establishing the Ramanujan Institute of Mathematics at the University of Madras as one of the advanced centres of mathematical research.

In the field of Medical Sciences, this volume includes pioneers like Drs. K. V. Krishnan and Bishnupada Mukherjee. Dr. Krishnan was a reputed specialist in preventive medicine and public health. He served India and Afghanistan with distinction. Dr. Mukherjee contributed a great deal to the development of research on pharmacognosy and drug chemistry and the Central Drug Research Institute of which he was the Director owes a great deal to his great leadership. He held responsible positions in different organisations which includes the Vice-Presidentship of the Indian National Science Academy and General Presidentship of the Indian Science Congress Association.

Prof. R. V. Seshaiya was almost synonymous with Indian Zoology. His works on molluscs are regarded as classics in the field of malacology. He was responsible for establishing a Centre of Advanced Study in Marine Biology in the Department of Zoology at the Annamalai University.

Dr. L. A. Ramdas was a well-known physicist and meteorologist. His interest ranged from micro-meterology, radiation, soil physics, problems of plant physiology and crop-weather relationship. He was responsible for the development of the Department of Agricultural Meteorology.

In B. Bhowmik, we had a pioneer X-ray engineer who made remarkable contributions in the field of high voltage engineering and his equipments found wide use in various laboratories and hospitals in India. He was the first to develop indigenous X-ray equipments in India.

On behalf of the Academy, I express my sincere thanks to Dr. G. S. Venkataraman and Prof. A. N. Mitra, the Editors of Publications for bringing out this volume. I am equally thankful to all the contributors who were in one way or the other associated with these great Men of Science.

I record my appreciation to Shri S. Rajan, Dr. M. Dhara, Shri J. Saketharaman and to all the members of the Editorial Staff of the Academy for their valuable cooperation and assistance during the preparation and production of this volume.

2 January, 1984.

A. K. SHARMA
President

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N. N. Semenov

NARENDRA NATH SEN GUPTA

(1889–1944)

Foundation Fellow 1935

NARENDRA NATH SEN GUPTA was born on December 23, 1889 at Tentulia in District Faridpur (now in Bangla Desh) in a Vaidya Brahmin family (*Purba Banga*). His father was Tarinicharan, a lawyer. In the context of a reference to parentage, it is necessary to mention here the community background,* (*see footnote*) which only helps us to understand how highly placed was the term "Vaidya".

EDUCATION

Naren had his schooling at the Government District School in nearby Rangpur. While studying, Naren took time off to join the *Tol* (oriental institute) of Pandit Jadaveswar Tarka-ratna. The interest in Sanskrit displayed by him in early childhood was sustained throughout his life and influenced the direction of his thought and style of writing.

The year 1905 is memorable in the history of Bengal for the outbreak of the Swadeshi Movement, which called for the boycott of British goods and Government

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*The Vaidyas (corrupt form "Baidya" meaning "physician") are a highly respected caste found in Bengal proper. They claim pure Aryan descent and according to Rislay (1891) their complexion and features lend support to the claim, which is reinforced by the tradition that they like many other high castes of Bengal, originally belonged to Kanya-kubja, the seat of Holy Brahmins. Manu, however, makes no mention of this caste in his works. He does speak of *Ambasthas,* the offspring of the union of a Brahmin father with a *Vais'ya* mother, and who practised medicine. The *Skanda-purana* adds that the Brahmin father was Galava Muni, a son or disciple of Vishwamitra, and the *Vais'ya* mother was one named Birbhadra, and that their son was variously known as Dhanwantari, Amrit Acharya, or Ambastha. The term *ambastha* was explained as "belonging to and known through one's mother (*amba*)." The designation *ambastha* was gradually replaced by *Vaidya* in virtue of the profession of medicine by the members of the community.

But the emphasis on the maternal *Vais'ya* origin survives to this day in the suffix "Gupta" in the surnames of the Vaidyas.

Though the genealogies of the Vaidyas are traceable to the Seventh century, the available evidence suggests that the scions of this community ruled over a portion of Bengal from 1010 to 1200 A.D. The most famous of these was Ballal Sen. He divided the community into *Kulins* and *akulins* (pure and impure); the former wore the sacred thread compulsorily and the latter optionally. When he took a very low caste wife, a section of his community led by his son, protested by tearing off their sacred thread and migrating to a distant part of the country, where they gave rise to two sub-sects, Banga and Barendra. Those members of the community who acquiesced in the impropriety and stayed on in the kingdom came to be known as *Rarhis.* The community, thus came to be divided into four sub-castes : *Panchakuti, Rarhi, Banga and Purba-Banga* (*Barendra*).

Schools. Young Naren responded enthusiastically to the call and joined the boycott. As a counter measure, the Government School imposed a fine on all those who had taken part in the school boycott. Naren with some of his other compatriots refused to pay the fine, and had to quit the school. To provide for the education of pupils who had left Government Schools, the Bengal National Council of Education floated a National School at Rangpur, to which Naren was admitted along with his friends. After finishing school at Rangpur, Naren proceeded to Calcutta for further studies. In 1907, he joined the Bengal National College at Jadavpur, and opted for the literary course, studying simultaneously English, Bengali, Sanskrit, Pali, Marathi and Hindi with the intention of going in for research in Ancient Indian History under Radha Kumud Mookerji.

The Swadeshi Movement was ruthlessly suppressed by the British Government. The National Schools and Colleges languished for want of adequate teachers and students. To meet this situation, the Council decided to send seven outstanding students of the National College for education abroad, so that later on these students might serve the College as teachers on a missionary basis. Narendra Nath Sen Gupta was one of these seven. In 1910, he was sent to Harvard University for higher studies in Philosophy and Experimental Psychology.

At Harvard : 1910–15

He joined the Department of Philosophy, of which Experimental Psychology was an adjunct. He took ancient philosophy with Palmer, modern philosophy with Perry and Santayana, general and experimental psychology with Munsterberg and Holt, animal and comparative psychology with Yerkes, metaphysics with Royce, economics with Taussig, and Government with Lowell. He was able to complete the four-year degree course within three years, and obtained the Bachelor's degree *magna cum laude* in 1913, and was admitted to the prestigeous *Phi Beta Kappa* fraternity. He won many prizes at Harvard, and was placed 27th in a class of 447 graduates. In 1915, he earned the Ph.D. degree with a dissertation on anti-intellectualism in contemporary epistemology.

Professional Career

At Calcutta University : 1915–28

Dr Narendra Nath Sen Gupta returned to Calcutta in August 1915. By that time, the course in Philosophy in the National College had been abolished and he was relieved of the obligation to serve the College. Sir Asutosh Mookerji seized the opportunity to use Dr Sen Gupta for building up a Department of Psychology in Calcutta University. Pending the formalities of creating a new Department, he was attached to Philosophy Department, headed by the late Dr S Radhakrishnan. Within a year, the new Department had been created and was put under Dr Sen Gupta's charge. The Department was the first of its kind in the country. Dr Sen Gupta not only planted the sapling of Psychology in the country, but also nurtured it, until it acquired firm roots. In this respect. he was the WUNDT of India.

During the first few years of his stewardship of the Department his main task was to prepare colleagues, assistants and workers to meet the needs of the growing subject. A medical man, interested in psychoanalysis, found in the newly established Department a haven for furthering his speciality. He joined the Department as a special student, and earned the first D.Sc. degree in Psychology with a thesis on the concept of repression. He became a part-time member of the Staff and rose to be Professor. Another student of Dr Sen Gupta and later his colleagues obtained the second D.Sc. degree in Psychology with research in the orthodox area of Psychophysics.

In addition to teaching and research, Dr Sen Gupta had also to be active in organizing the profession of psychology. In 1924, he induced the Indian Science Congress Association to open a Psychology Section and he presided at the first session of the section in 1925. The same year he founded the Indian Psychological Association and was elected as its first President. When the Indian Philosophical Congress came into being, he became its first-Secretary and the first-President of its Psychology Section. In 1926, the Indian Psychological Association launched upon the publication of the *Indian Journal of Psychology* under his editorship.

At Lucknow University : 1929–44

As a result of the efforts of Dr Radha Kamal Mukherji, Professor of Sociology and Economics at Lucknow University and one-time mess-mate of N.N. Sen Gupta at National College and co-author of *Introduction to Social Psychology* the latter joined Lucknow University in 1929 as Professor of Philosophy with the understanding that he would organize the teaching of Psychology in Lucknow University. A lumpsum was sanctioned for setting up a psychology laboratory. The sum was used to purchase necessary apparatus, but in the absence of a recurring grant and supportive laboratory personnel the plan to develop psychology in Lucknow University remained dormant for almost a decade.

In 1939, a number of circumstances combined to promote the growth of psychology in the University. A couple of rooms were placed at the disposal of the Department, a small recurring grant sanctioned and a laboratory bearer and assistant provided. The stored apparatus was put into circulation and laboratory instruction began on a non-examination basis. A Diploma in Psychology course was started : it was given in the evenings for the benefit of teachers and others engaged in full-time work. Professor Sen Gupta's own involvement at the time in the applications of psychology to the problems of education, led to the demand for a course in psychology for senior teachers and educational administrators. To meet this demand, the Department instituted a one-year evening course leading to the degree of Bachelor of Educational Science. The course was to start in July 1944, but on June 13, 1944 he passed away.

Family

While engaged in academic pursuits, Sen Gupta found time to set up family. In 1917, he married Kamala Debi. She gave birth to one son and three daughters

(the last two twins) before she was snatched away by fate. He consoled himself by marrying in 1926 his wife's sister, Sabitri Debi. She gave birth to a son and daughter but both she and her infant son were the victims of the 1934 Bihar Earthquake; the daughter survived.

The tragic death of his wife and son in 1934 Bihar Earthquake had affected him intensely, but he tried to put a brave face on it. The suppressed grief resulted in an attack of cerebral thrombosis in 1935 from which he did recover but could not regain his original health. Conscious of his failing health, he decided to reduce to writing whatever he had to say. He overworked himself in the completion of his creative writings and suffered a second stroke. It proved fatal. He left behind him a son and four daughters and a host of friends, students and admirers to mourn his untimely death. A medal to perpetuate his memory in the Department was instituted by his students and colleagues. A special issue of the *Indian Journal of Psychology* called **Sen Gupta Volume** was published in 1944.

Contributions to New Knowledge

Books

In collaboration with Radha Kamal Mukherji, Sen Gupta wrote the *Introduction to Social Psychology* (1928). Their collaboration was facilitated by their friendship of National College days and the close proximity of their residences in Calcutta where Radha Kamal Mukherji used to spend his vacations. The content of the book is mostly the handiwork of Sen Gupta but the language is largely that of Mukherji. The ideas contained in the book are largely those of Sen Gupta. This is testified by the fact that the Foreword to the book is written by R. M. Yerkes, a teacher of the former at Harvard. The book was originally entitled by the authors *Mind in Society*; the change to the present title was accepted at the suggestion of the publishers. The pattern of writing a book on social psychology by a psychologist in collaboration with a sociologist, exemplified in this book was found so attractive that it persists upto this day. According to one reviewer, the book proved to be one of the top dozen books on the subject, its rank being perhaps the seventh.

Presently, the book is out of circulation. It dealt with the most vital topics in social psychology like anticipations of social psychology, standpoints in social psychology, origins of group life, social character of behaviour, mechanisms of social behaviour, social adaptation of ideas and feelings, the role of mind in group formation, the group as a value, contact of groups, psychological basis of culture, economic roots of social behaviour and culture, regional evolution of culture, legacy of race, social change, leadership and group solidarity, emergence of the crowd, classification of crowds, analysis of crowd behaviour, functional and regional groups, social neuroses, behaviour in isolation and psychology of progress.

The book endeavours to *bring together the data and standpoints both of psychology and sociology for the purpose of analysing collective behaviour* (p. vii). The task of social psychology is conceived to lie *not only in explaining what is generally regarded as a social fact, such as a crowd emotion or group solidarity, but also in tracing from*

its beginnings the influence of the group on the content and pattern of the individual's mind and behaviour (*loc. cit.*). It addresses itself to the task by trying *to reveal the mechanisms through which the group shapes the course of mental life. The psychoses arising in social environment do not differ in quality from individual psychoses. Both of these can be represented as correlates of the stimulus-response scheme*(*loc. cit.*). Throughout its analysis, the book persistently attempts *to apply the more generally accepted principles of attention, emotion and action to the explanation of all complex forms of group behaviour*(p. ix). The concept of gregariousness, or suggestibility is not employed and the premises and conclusions of psychoanalysis are not followed. The standpoint of the book, thus clearly reveals the impress of the thinking of Sen Gupta's contemporary at Harvard, Floyd H. Allport as exemplified in the latter's *Social Psychology* and which is coming into its own again today through the emergence of experimental social psychology, spearheaded by men like zajone. It is remarkable that Sen Gupta eschewed the premises and conclusions of psychoanalysis, despite his *gherao* by psychoanalysts in the Department at Calcutta.

Commending the standpoint of the book R. M. Yerkes in the Foreword, observes that *group consciousness and behaviour are readily and reliably observable and describable, controllable and experimentally modifiable, as are similar phenomena in the life of the isolated individual. This suggests the possibility of an experimentally developed social psychology and sociology. The data gathered by such an experimentally developed social psychology should lead to the discovery of principles and laws of biological and psychobiological aggregation. The book interests him as a general and systematic preparation for more intensive observational work* (pp. xiii–xv).

After this pioneer work on Social Psychology, a publication entitled : *Heredity in Mental Traits* came out in 1941 which consisted of three lectures delivered by Professor Sen Gupta in the Faculty of Science of Lucknow University. It was dedicated "To those who told us of the truthward Way." (*Isopanishad*). The inquiry into the problem of heredity in *mental* traits is prompted by a desire to find a scientific basis for educational, industrial and social planning exemplified in current programmes of selection and guidance. Both selection and guidance call for a careful estimate of handicaps and abilities. The value of these for purposes of prognosis, depends on whether the handicaps and abilities are inherited or acquired. The book, therefore, aims to sift the evidence bit by bit about the hypothesis of inheritance of mental traits.

The book begins with a preliminary clarification of the concept of inheritance of mental traits. A trait is said to be mental if : (i) it is observable as a specific psychic quality e.g., image-type, sensory acuity; (ii) it exhibits itself in a specified form of behaviour, which maintains itself under varying circumstances, e.g. fear or anger response; (iii) it is durable in introspection or behaviour in the sense of describing similar time-curves or similar quality-phases on different occasions; and (iv) it can be easily modified through a change in external conditions e.g. Synaesthesia. A mental trait is said to be inherited if (i) it is found to be possessed by a number of ancestors and a number of descendants, and (ii) it exhibits a correspondence or correlation between trait-values of ancestors and those of descendants e.g. musical

ability. Given these definitions, Sen Gupta proceeds to consider the methods of studying mental inheritance. These he finds to be three : statistical examination of data; tracing the pedigree of persons possessing a particuar, specially rare, trait; and the study of siblings and twins under different conditions of nurture and environment.

After the preliminary clarifications, Sen Gupta proceeds to examine the evidence for the inheritance of sensory and imaginal traits (ch. II), of pathological traits (ch. III), of intellectual 'dullness' and 'subnormal' ability (ch. IV), of amentia (ch. V), of talents and abilities (ch. VI), of intelligence (ch. VII), in relation to family (ch. VIII), to class and location (ch. IX), to race (ch. X), of character of a race (ch. XI), of impulses, dispositions and personality-types (ch. XII), with special reference to the relation between personality type and temperament (ch. XIII). He finally outlines the theoretic approaches to the problem of mental inheritance (ch. XIV), and ends with a summary of the findings.

He arrives at the conclusion that the evidence for the inheritance of some traits is clear (visual acuity, dark-adaptation, colour-blindness, synaesthesia, eidetic imagery, amentia); it is negative for some others (talents, abilities, intelligence); it is doubtful for still others (character, desires, impulses); and it is plausible for personality-types. There is no proof for the general proposition that all mental traits are inherited; there are proofs of varying weights in support of the hypothesis that some mental traits are inherited (p. 194).

The book reflects Professor Sen Gupta's interest in Eugenics acquired during Harvard days. The Bussey Institute of Eugenics at the University maintained that its work in applied biology had bearings on psychology and Yerkes in his treatment of Comparative Psychology advocated control of inheritance. Sen Gupta was influenced by both the views and wanted to check on their soundness through a detailed examination of the phenomenon of inheritance of mental traits. While the Eugenics Movement withered away because of its questionable *bonafides,* and the onslaughts of the environmentalists, its hereditarian emphasis has received a shot in the arm through the recent development of microbiology and the work of Lorenz in ethology. Behaviour genetics is today a respectable field. It is remarkable that Sen Gupta could anticipate the modern idea of linking certain abilities and disabilities with "genes".

Sen Gupta's book on *Mental Growth & Decay* came out in 1942. The book marshals data on questions of mental growth and decay. The data are claimed to be exhaustive, but only recent. The book is divided into three parts. In part I, the case is first made out for studying *mental* growth and decay, independently of physical growth and decay, for there is no perfect correspondence between physical and mental growth and decay. Next, it is pointed out that the approach to the problem of mental growth and decay must be in terms of psychological tests, standards and criteria. Finally the course of sensory, emotional and language development is traced and the growth of complex psychophysical functions is presented, ending with a discussion of the general character and principles of mental growth.

In Part II, the concept of "mental profile" is introduced, and the profiles of habits and moods, in early childhood, from age seven to eleven and from age

eleven to twelve in adolescense and in maturity and after, are presented and illustrated ending with a discussion of the basis of mental profiles.

Part III is devoted to a discussion on the phenomenon of mental decay. The factors in the normal decline of mental functions are first brought out; the effect of age on sensory and motor functions is taken up next; a picture of mental decay in approaching old age and in later old age is then presented and a discussion of the general character of the process of decay and disintegration brings the Part to a close.

The book concludes with a conspectus of the standpoint and of the process of growth and decay. In the latter context, Sen Gupta characteristically presents the Indian point of view about ageing.

In the Indian tradition old age is called *Vardhakya* (increase); it is not an age of crisis but of fulfilment, says the Sanskrit verse :

Sarpastyajati Chharmmani ।
Vrukshastyajati Valkalam ॥
Atitya Vasaanah Prajnah ।
Vardhakyamadhigachchati ॥

Meaning : The serpent sheds its skin,
The tree throws out its bark,
The wiseman gives up his desires,
And reaches the maturity of the old age.
(in the fulfilment of the self)

Other Writings

In addition to the three books discussed above, Sen Gupta produced between 1926 and 1944, 76 papers and articles (some of which are incorporated in his books). And he left for posterity his *magnum opus* on *Mechanisms of Ecstasy* in two volumes, which remains unpublished todate. Two of his articles have appeared in Jubilee Volumes of S. C. Roy and of Asutosh Mookerjee. Excluding these, the rest have been published in journals belonging to diverse disciplines.

Psychology

His writings in psychology proper are spread over many fields : historical and systematic, social, experimental, developmental, ethnic, criminal, religious and occupational. Some of his papers bear on several fields at the same time, hence in the exposition of his contributions to different fields of psychology, some amount of overlap is inevitable.

He began the first issue of the *Indian Journal of Psychology* with a look at the present development and outlook of psychology. Later, he wrote a paper on Gestalt theory; it was one of the three papers on this system at that time. His paper on the contribution of abnormal psychology to normal psychology was written to mark the celebration of the Silver Jubilee of Indian Science Congress Association. His historical paper on Freud's contribution to general psychology

was prepared to mark the jubilee of the Psychoanalytical Society, founded by his colleague and successor, G. S. Bose. He was specially at home in the task of clarifying bothersome psychological concepts. He specifically, analysed the concepts of attention, instinct, mental inheritance, dimension of mental life. He was eager to advance theoretical formulations for resolving controversial psychological issues. He offered suggestions for a theory of time perception; and outlined a dynamic theory of space perception. His most thought-provoking ideas are found in his Concept of the Mind, which will be discussed under his contribution to Philosophy.

Experimental—In this field, Sen Gupta produced four studies, three in collaboration with his students and one on his own. In the first study, he took the help of Samanta to record the involuntary movements of the middle finger of the right hand of 10Ss. Three kinds of curves were found : wavy, linear and combined. The oscillations showed a slight increase when Ss were exposed to harmonious music. The study was undertaken to throw light on finger tremors treated by physicians. In the second study, in collaboration with S. K. Bose, he tried to verify the hypothesis that the distance between two objects appears smaller when viewed with one eye instead of with both the eyes. The study, however, found threshold values very much smaller than those reported by Wundt in similar inquiries. The third study, again undertaken in collaboration with S. K. Bose, explored the difference between definitely-directed and indefinitely-directed attention. Different sets of psychic factors were found to operate in the two cases; the former was twice more efficient than the latter in a simple learning experiment. The last study aims to determine the error-values in a line (2.5cm in length) visually presented and then reproduced on paper (after removing the stimulus). It was found that the process of motor reproduction of a visually-presented length is mainly guided by an attitude with an inhibitory reference; the accuracy of reproduction depends on the timing of the emergence of the attitude discovered.

Social and Ethnic—Sen Gupta's paper, jointly with C. P. N. Sinha, on mental work in isolation and in group has become a classic because of its improved measure of the extent of social facilitation by discounting the increase due to practice. Marital adjustment was another concern of Sen Gupta where he wrote, in collaboration with Radha Kamal Mukherji, on binders of marriage, marriage and personality, marriage and religion and independently on psychological factors in the stabilization of marital relations.

In ethnic psychology, he began with a survey of the field, tracing the antecedents of race psychology in the attempts of social scientists to understand the nature of mental states underlying social formation and emphasizing the unquestionable value of psycho-physical tests in studying race differences. The survey was followed by reviews of the earlier and recent studies of racial intelligence and culminated in a full-dress discussion of the race mind, in terms of the frequency of marked abilities in different races of England, France, Germany, Italy, and Russia in terms of frequency of sensory acuity, colour-blindness, colour preference, mental work and fatigue and special sensibilities in full-blood Indians, mixed-blood Indians and Whites, in terms of reaction time of different racial groups in England, Sarawak,

Caucasian male, Chinese male, Japanese male, etc. and in terms of different scores on crime and suicide in Denmark, Scandinavia, North Germany, South Germany, England, Australia, Wales, Ireland, Spain, Russia, North Italy and South Italy. Critical reflection on the data on race mind does not support the explanation of differences in ethnic terms necessarily.

Educational—Sen Gupta's writings on educational psychology (as the field was then conceived) touch on four topics. First, his studies on the development of growth of speech in relation to age and mental growth and of deterioration of psycho-physical functions in old age, both incorporated in his *Mental Growth and Decay*; second, his studies on intelligence, its relation to class and vocation, its social setting and its level in relation to the setting of class and progress; third, his analysis of the nature of instinct, especially in its new settings; and fourth, his discussion of the methods of vocational guidance.

Criminal—Sen Gupta's works in criminal psychology were due to an historical accident, namely, the founding of a journal in criminology (*Penal Reformer*) under the editorship of his junior colleague. He first articulated the relationship between psychology and the prisoner; he next described the criminal personality in the light of certain psychological tests, then indicated a psychological approach to inheritance of criminal behaviour and finally elucidated the relationship between crime and social unrest.

Religious—Sen Gupta's interest in anti-intellectualism was in keeping with James' pluralism and pragmatism, and Bergson's intuitionism. Together, they suggested the value of mystical experiences, religious practices and institutions as aids to mental equilibrium and integrity. James' *Varieties of Religious Experience* provided a model of such thinking. The tragic death of his wife and son in 1934 brought his interest in religion to the fore and became the focal point of his writing and thinking during the last decade of his life.

Like James, he found evidence of psychic disorders as a phase in the life of certain mystics; he drew attention to the phenomenon of "divine" madness. He spelled out various kinds of experiences in the life of a mystic, sense of sin and imperfection of joy, delight and consolation and the sound experience connected with the "unrecited mystic syllable." He described the doctrine of sudden ecstasy in Shaivism and Vaishnavism, and the dance of frenzy and ecstasy. He was more concerned with the techniques of spiritual advancement. He drew attention to two techniques of mystic contemplation enunciated in Shaivism, to the practice of concentration with material aids in Buddhism and Kashmir Shaivism, to *asparsha yoga* and to the phenomenon of recital. In all these writings he was not merely content to describe the experience or practice, but to offer its psychological interpretation. His further researches in the life of mysticism are incorporated in his unpublished volumes on Mechanisms of Ecstasy. He entrusted to the author the task of describing and interpreting "sensory phenomena in mystic life," the results of which are published in part.

Philosophy

Sen Gupta not only worked for his research degree in Philosophy, but was also

a Professor of Philosophy. He was the Founder Secretary of the Indian Philosophical Congress, which he attended from time to time and to which he submitted papers and of which he became the General President in 1940. The papers that he presented to the Indian Philosophical Congress or the Oriental Conference are taken here to be his writings in Philosophy, although they deal with psychological topics. Conversely, his writings in psychology of religion can very well pass off as writings in Philosophy.

His paper on psychological explanation is an exercise in the philosophy of psychology. He approached the philosophical problems of personal identity and of self from the psychological angle. His observations on the psychology of isolation have a bearing on the doctrine of "withdrawal". His Presidential Address on *The mind in its new setting* is a notable contribution to the Philosophy of Mind. Mind is first viewed in the setting of the characteristic of naturalism of the 18th and 19th centuries; mind was reduced into matter or variants of material energy in this setting. The quantification of mental life attempted in psycho-physics was intended to confirm the hypothesis of naturalism. Another attempt at the confirmation of Naturalism was to reduce to mental functions to physiological and often to an anatomical base; the attempt passed through two stages. In the first stage, mental life was taken to be the function of a single bodily organ or a vital substance; the second stage is instanced by phrenology and schemes of cerebral localization. According to him, mind is not subject to quantification or physiological reduction. Yet it is not outside the realm of empirical inquiry. It is a reality within the scheme of natural phenomena when Nature is not viewed in the narrow mechanistic context given to it in the 19th century. "*The mental functions represent one order of natural events that interlace at every twist and turn with other types of events and build up in this manner complex though concrete patterns of phenomena, personal, social and racial*". (p. 16) "*The interlacings are bodily, physical and geographic. In every mental operation, the fact of such interlacing is manifest. Each interlacing gives an 'experience' in which there are polarities but no divisions.*"

He distinguished between two orders of mental functions, the amoeboid and the dimensional. In the first, the mental function incorporates within itself the object to which it is directed; this was named *empathy* by Theodore Lipps. The second function is commonly believed to be devoid of all sensory content and yet it "contains" the sensory content in a "nutshell". It is exemplified by attitudes and dispositions, *bewusstheit* and *einstellung* of structural psychology, and in the theories of Kurt Lewin, and E. C. Tolman. The Indian conception of the four *vrittis* (*samśaya, niśchaya, garva, smarana*) and *antahkarana* also refer to the dimensional function. The amoeboid functions are tied to life's physical plane; the dimensional functions to the cultural and social milieu. The two orders of functions maintain something like an inner reciprocity.

Sen Gupta draws the implications of his analysis of mind. "People must live by bread.... At the same time, the social and cultural stimuli must be permitted to operate on the mind.... Whatever disturbs this balance impedes the course of culture and civilisation and throws a barrier along the path of mind's normal evolution.." (p. 37) "Mental life when forced down to its earliest level

becomes a restless hunger that prompts man to venture out into the world and to extend his mental prehensiles at things so that the body may live. But it is the death of the spirit: here, normal evolution of mind stops." Hence, man commits a "crime against nature and culture alike". (p. 38)

Education and Anthropology

In the field of education, Sen Gupta examined the alternatives to the essay type examination—interview, mental tests and psychological examination indicated the legitimate use of mental tests and psychological examination, and warned that "*mental tests that abound in the West are not readily applicable to the Indian conditions. A mere translation.. is not likely to yield any result of significance. It will be necessary to reformulate and restandardize them.*" (p. 266). When some educationists mooted the idea of changing the British pattern of University offerings in favour of the American, Sen Gupta was requested, because of his American experience, to explain the American scheme of elective courses. He did so in a couple of articles. Similarly, when the authorities became sensitive to the problem of country's enormous illiteracy, he offered a psychological approach to the problem of adult education and drew attention to certain aspects of the question of liquidation of illiteracy.

Towards the end of his career, he began to contribute papers to the Anthropology Section of the Indian Science Congress Association. Notable among these were his studies of racial intelligence, his discussion of Shaman personality, and his account of mental diseases among primitive people. He offered a psychological interpretation of culture traits in S. C. Roy Jubilee Volume.

Teacher and Man

Teacher

N. N. Sen Gupta's commitment to academic pursuits was total. Of the three-fold duties of a university professor—teaching, research and administration, his entire time was spent in teaching and research. Headship took little of his time, because of the democratic manner in which he conducted the affairs of the Department. He looked upon participation in University Politics as a distraction and studiously kept himself away from temptations to rise in the administrative hierarchy. In this respect, he was the very opposite of his juniormost colleague, who was as far from teaching (nothing to say of research) as he was near the vortex of university politics. When the author joined the Department formally as a lecturer, Professor Sen Gupta told him that there were two ways of rising in the University—the way of politics and the way of hard academic work—and that he was free to choose either (both the ways being exemplified in the Department itself).

He was an outstanding teacher, judged by any standards; quality of lectures, manner of presentation, personal qualities of sympathy and affection for students. He was more than a teacher—a Preceptor, a *Guru* in the Indian tradition. His lectures were always well prepared, content-rich, highly analytical, lucid and

stimulating. He would deliver them in a loud and clear voice that rang in the ears after the lecture was over. In the latter part of his life, he had his undergraduate lectures on metaphysics reduced to writing (perhaps with the intention of publishing them later on the model of W. E. Hockings, *Types of Philosophy*). He would occasionally send a Research Fellow to the class to dictate his lectures from the type-script. This gave the student some experience and confidence in handling a class, without affecting the standards of teaching. The practice of dictation by a teacher is frowned upon as educationally unhealthy, and in some universities there is rule that a teacher cannot carry to the class even a slip of paper. There are, however, teachers who deliver their lectures at a speed that the student can take them *verbatim* (and the author had an Oxford don as one such teacher); and it is deemed quite proper for a savant to read aloud from his manuscript. The practice of dictation by a teacher can be defended by making a distinction between dictation of "notes" and of a learned work. The real danger in the latter case lies in the work being published under the authorship of some unscrupulous student.

Research was somewhat of a novelty for teachers of newly founded universities. A good Master's degree was regarded as the passport to the highest academic post and many professors possessed that only. But, Sen Gupta had obtained a research degree from a top-ranking American university and his love of research was infectious. He gave freely of his time to students, colleagues and visitors for discussion of research problems. In his zeal to encourage research (but more out of his unbounded love for students), he even went to the extent of dictating whole papers to his students to be published in *their* name. Many of his students in top positions today (including the present author) have benefited from his generosity in this respect, and their early papers are actually those of their *guru*. His zeal for research did not lead him to make any compromises with high standards of research and publications. He insisted that every piece of research must make some original contribution and that it was not enough to describe a phenomenon or a fact but one had to go on to offer some explanation of the discovered fact or phenomenon. He was an enemy of plagiarism. Once a research student submitted to him two papers (Forms of forms of Aristotle and Monads of monads of Leibnitz", and "Idea, Ideal, Idealism") for opinion about presenting them to Indian Philosophical Congress. The papers were so well written that Sen Gupta became suspicious of their real authorship and asked the present author to investigate. He was able to locate the first paper in a recent issue of a philosophical journal and the second too had a familiar ring. He gave his findings to Professor Sen Gupta whose reaction was to get rid of that student getting him a job in an intermediate college.

The author observed him in the process of his creative writing. He would go through the relevant literature, put flags in books and journals at pages to be used, think again and again, would go about the best way of arranging the available material into sections and subsections, number the points in each section or subsection, draw inference from the material in each section, work out a suitable literary beginning and end of the paper or chapter, and then proceed to write. He would take a sheat of plain white paper, folded lengthwise, and write on it with

a long thick pencil. He would freely use an eraser to change his draft. He would then give his manuscript to the typist. He would go carefully over the typescript, make changes and get the draft retyped. He would continue this process until he was satisfied or had to meet a deadline for publication. He made extensive use of charts, tables and diagrams to score his point. He used the system of adding notes on each chapter, instead of giving footnotes pagewise. In conformity with the norms of publication in his time, no bibliography was given at the end of the book.

Man

In physical appearance, Professor Sen Gupta was tall and slim, clean-shaven with fine features and a wheatish complexion. He was one of the best dressed university professors. His official dress was a three-piece suit (of silk in summer and serge in winter), the insignia of Phi-Beta-Kappa dangling from the gold chain of his pocket watch kept in his waist-coat. A cigar would be protruding from his mouth (he had to give up smoking after his first stroke). He would take snuff frequently. In his hand there would be a brief-case while going about academic business; during social calls or while walking, he would carry a walking stick. His dress at home consisted of *Kurta* and *Dhoti* (tied in Bengali style).

He lived in style but not ostentatiously. He maintained a car and a driver. When World War II broke out and petrol became scarce, he went in for a horse-driven *buggie* and gave a temporary reprieve to his chauffer. He was fond of good food but did not enjoy eating it alone. His love for hospitality was enormous; no student ever returned from his residence without enjoying tea and refreshment. His students and friends also did not fail to call on him when in Lucknow. Subhash Chandra Bose, one-time his student, made it a point to visit him when he came to Lucknow in 1938.

He was a nationalist to the core. His whole-hearted plunge into the Swadeshi Movement and his education in national school and national college are proofs of his early patriotism. At Harvard, once President Lowell in a public lecture made some adverse remarks against India, Sen Gupta rose to protest against them. When Tagore visited Harvard University it was as a result of Sen Gupta's efforts that the former got a chance to speak there. This was before Tagore received the Nobel Prize. A noteworthy aspect of his nationalism was his determination to raise the standard of our journals to international levels. He urged fellow academicians to publish their best research in Indian and not in foreign journals. He himself followed this rule and the author had taken his advice to heart at the cost of being internationally unknown and unsung.

His integrity in monetary matters was exemplary. After his first stroke, he needed a cup of tea after his teaching and before beginning creative writing. He set up a tea-hour in the Department, all at his own expense. The water for tea used to be boiled on a kerosene stove. With the outbreak of World War II, kerosene was rationed and the use of stove posed a problem. The suggestion was made that a tin of kerosene could be had officially for the ostensible purpose of smoking the kymograph paper but actually for the stove. Sen Gupta firmly ruled out the suggestion and went in for a charcoal *angethi* (stove). The lighting

of the *angethi* with waste paper and the resulting billowing smoke was an amusing sight in the University but it symbolised the Professor's integrity even in small matters.

Not only in matters concerning public money but also in academic matters, his integrity was exceptional. He never took the help of students or colleagues in the confidential work of examining answer books or theses or totalling or entering examination marks, or of setting question papers and he was not open to influence in marking. A noteworthy aspect of his academic values was his utter unwillingness to claim joint (much less first) authorship of any piece of research supervised by or discussed with him. He justified his stand with the argument that the addition of one or more papers to his credit did not substantially affect his reputation, already firmly established, but the publication of a paper by a young man on the threshold of his career could make a difference in getting a job or losing it. His stand is in sharp contrast to present day norms according to which a supervisor considers it his right to associate his name with the student's research, or a Head claims this right in virtue of his office.

The development of Psychology in the country was a mission for which Professor Sen Gupta worked indifatiguably and successfully. His pre-eminence in Psychology is undisputed, judged by the many firsts to his credit, his publications, honours and distinctions. He was the DOYEN OF INDIAN PSYCHOLOGISTS.

Acknowledgements

In the preparation of this Memoir, the author is indebted to the following : Dr R. G. Chatterjee, Professor-Head, Psychology Department, Calcutta University; Professor S. K. Bose, Retired Professor-Head, Psychology Department, Calcutta University; Dr R. D. Misra, Lecturer in Philosophy, Lucknow University; Dr H. S. Asthana, Professor-Head, Psychology Department, Saugar University; Dr N. C. Panchbhai of the Anthropological Survey of India, Calcutta ; late Professor Sen Gupta's son (Arun), daughter-in-law (Manjari), daughter (Archana) and nephew (Atul Dasgupta).

Raj Narain*

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S. P. Asharkar

SHANKAR PUROSHATTAM AGHARKAR

(1884—1960)

Foundation Fellow 1935

Birth and Early Education

Shankar Puroshattam Agharkar was born in a family of Chitpawan Brahmins called Datar hailing from a village called Kolthare in the Dapoli Taluka of Ratnagiri District, Maharashtra State. One of his forefathers acquired the Khoti of a small village called *Aghari* and hence the family came to be known as Agharikar or Agharkar. A branch of the family left Kolthare for Harnai where it settled down. It was in this branch that Professor Agharkar was born at Malvan on November 18, 1884. His early life, seen through many misty years, appears to be quite exciting though not easy. Professor Agharkar's father, Shri Puroshattam Jayaram Agharkar, was an overseer in the P. W. D. Department of the Bombay State which then extended from Sindh to North Kanara. Due to his frequent transfers, he continually had to face the problem of his children's education. As a result, Professor Agharkar's primary and secondary education was completed in half-a-dozen schools at Khanpatan, Ratnagiri, Belgaum, Siddapur, Harnai and Dharwar. It would surprise many to know that his second language at that time was Kannada and that he had attained the necessary proficiency in it. Fifty years ago facilities for education in Karnatak, as elsewhere, were very meagre. The story goes that in one Anglo-vernacular school he attended, there were only two teachers. One was too busy to teach and the other rather disinclined to do so; and, therefore, more than once, an advanced student in the school was asked to conduct the class. No wonder the choice used to fall on young Agharkar who did the job well and liked to do it.

Formative Influences

During these formative years, his mother, a religious and pious lady, exercised profound influence on him. She was responsible for creating a deep sense of devotion and spirituality in him. He was required to read to her at night popular Marathi *pothis* like Ramvijaya, Harivijay, Pandav Pratap etc. when his father was out on his tours. He was also required to perform *Sandhya* daily after his thread ceremony.

Higher Education

In spite of hardships involved in travel and transport in those days, and frequent change of schools, subjects and curricula, Agharkar matriculated in 1901 from the Government High School at Dharwar and joined the Elphinstone College, Bombay, in January 1902. He took the B. A. degree in first class with Botany and Zoology as his optional subjects, with a few others. He was the recipient of the *"Bell Prize"* for his proficiency in English at that examination. It was during this period that his interest in Biological sciences was kindled and he took his M. A. degree in 1909 with Zoology, Botany and Geology. Prior to this, he was awarded the Lisboa Scholarship for practical Botany at the Grant Medical College in 1907.

Career

After the completion of post-graduate studies he was appointed Lecturer and Head of the Biology Department in the Elphinstone College, Bombay, and thus started on his career. He remained there from 1910 to 1913. Luckily, his tenure of appointment was of a temporary nature and frequently interrupted by long holidays. It was during these interruptions that he made notable contributions to Zoology. He was at home in collecting both animals and plants in the field and at making observations on their ecology, an example which should prove to be a source of inspiration to younger biologists. During 1911 and 1912, he explored the Western Ghats and discovered a fresh-water medusa, *Limnocnida indica* Annandale, from Tambi in Koyna valley, Medha in the Yenna valley, two places in the chain of Western ghats and at Dhom in the Krishna valley. *Limnocnida* is a genus of tiny jelly-fishes, in fresh water with 3–15 species in Africa. The species he collected turned out to be new and the facts regarding it were duly published in *Nature,* London.

During this period he was longing to devote more and more to research and wrote so to Dr Annandale, the then Superintendent of the Indian Museum, Calcutta, and later Director, Zoological Survey of India. Dr Annandale appointed him an honorary correspondent of that well-known institution in Calcutta in 1912.

During one of his trips to Calcutta he joined Dr Annandale in his work and was introduced to Dr Gravely who had then just joined the Indian Museum as an Assistant Superintendent. Dr Gravely trained him in the methods of collection and preservation, examination of microscopic preparations and histological techniques. Dr Annandale took special interest in teaching him the methods of collection, preservation and care of fresh water sponges of which Dr Annandale was a world authority. He also came in contact there with other eminent Indian scientists of Bengal. During this period he also used to work in the Royal Botanic Gardens at Sibpur and came in contact with Mr W. W. Smith (later Sir William Wright Smith, F. R. S.) who was then Curator of the Royal Botanic Gardens and a post-graduate teacher in Plant Taxonomy at the Calcutta University.

On June 6. 1913, his temporary appointment at the Elphinstone College, Bombay, came to an abrupt end, and the Education Department offered him an Assistant Teacher's post which he promptly refused, as it did not provide him any opportunities to continue his research work. To decline any Government job in those days was considered almost suicidal, and several of his well-wishers and elderly members of the family warned him of the error he was committing in refusing a secure and pensionable Government post. With courage so singular of him arising out of his deep convictions, he did so and continued to work silently at Calcutta.

Even in those days he had entertained a strong desire to be in Poona and to work amongst the band of selfless workers of the Deccan Education Society and its well-known College at Poona, the Fergusson College. The Governing Body of the Society, however, did not accede to his request for probationary life memberships. He was not able to realise his dream to be in Poona and do research work till about twenty five years later, when he retired from the Calcutta University and came to Poona and with his characteristic perseverence and capacity to organise, established the Maharashtra Association for the Cultivation of Science in the Law College Buildings with the cooperation of the late Professor S. L. Ajrekar, the late Professor N. V. Joshi, Dr P. J. Deoras, and active support of Rt. Hon'ble Dr M. R. Jayakar and Principal J. R. Gharpure. A detailed reference to the activities of this institution is made later.

Contributions to Scientific Knowledge

In 1913, as an Honorary Correspondent of the Indian Museum, Calcutta, he was invited to attend the Centenary Celebrations of the Indian Museum, and this occasion proved to be the turning point in his life. He remained at the Museum even after the celebrations and Dr Annandale kept at his disposal some of the adult and larval forms of net-veined midges (Blepharoceridae) from Kashmir. The adults proved to be specimens of a new species, *Philorus bionis* Agharkar, belonging to the genus *Philorus* Kellogg, which was not previously recorded from India. All the larval forms were described for the first time from India. Similarly, three other previously described species, viz., *Philorus ancilla* Osten-Sacken, and *P. yosemite* Osten-Sacken and *P. bilobata* Loew. from other localities were briefly dealt with and short ecological notes added. This work, though published so long ago, even today remains remarkable for accuracy of description and catholicism. Before going to the Indian Museum young Agharkar had collected a large number of specimens of animals and plants in his extensive tours from Kathiawar to Karnatak. The entire collection proved to be interesting in ways more than one. He reported a number of fresh water sponges from the Western Ghats, and added exhaustive ecological notes. They form a valuable contribution to our knowledge of this group. A new centipede was also collected by him and was rightly named after him by Dr Gravely as *Cryptorrhyptops agharkari.* Gravely in token of his high regard for young Agharkar. Incidentally, it may be mentioned here that both of them later made

extensive tours of the Western Ghats to survey the fauna, particularly to study the genus *Limnocnida* in its native habitat.

At the Calcutta University

His stay in Calcutta during this period turned out to be eventful for his career. At that time, the Calcutta University was vigorously growing under the care of that great educationist and humanist of Calcutta, the late Sir Asutosh Mookerjee. The munificent gifts of Sir Taraknath Palit and Sir Rashbehari Ghosh, led to the foundation of the Palit and Ghosh Professorships at that university. One of these was the Ghosh Professorship of Botany. The holders of these chairs had to be Indians born of Indian parentage. *When the Selection Committee met for the purpose they were not able to find a suitably qualified person for the post and Sir Asutosh Mookerjee asked Dr C. V. Raman, who had been selected for Palit Professorship of Physics, to suggest a suitable person for this post. Dr C. V. Raman was probably aware of Professor Agharkar's silent work in the Indian Museum. He, therefore, not only suggested young Agharkar's name, but also was instrumental in bringing about their first meeting which proved to be decisive. Sir Asutosh asked Agharkar to apply for the post of Professorship and enquired if he was willing to proceed to Germany for higher studies. To this Agharkar readily consented.* This instantaneous consent, given on the spur of the moment, became a source of some anxiety to him, as he had neither consulted his elders nor sought their formal permission. In the good old days, to go overseas even for higher studies, was considered a kind of sin and those who returned had to undergo some kind of penance. Apparently, he must have decided to undergo the necessary sacrament as he sailed for Germany on May 2, 1914, by '*S. S. Caledonia.*' Before sailing for Germany he attended the first session of the Indian Science Congress held under the presidentship of Sir Asutosh Mookerjee and took active part in it. In later years he was intimately associated with this august body for quite a long time. *He succeeded Dr C. V. Raman as one of the General Secretaries I.S.C.A. in May* 1924.

Even to the last days of his life Professor Agharkar recollected vividly how on the ship he met the Lion of Punjab, the late Lala Lajpatrai. It is said that the Great Lajpatrai was very discriminating in his food habits, and remarked that non-vegeterian Hindus were better, as they avoided beef scrupulously; but when a vegetarian becomes non-vegetarian abroad, he is not able to differentiate between beef and other kinds of meat and thus violates the traditional sanctity of Hindu religion by eating beef. Fortunately, Professor Agharkar like a devout Hindu was a vegetarian and remained strictly so till the very last.

In Europe

Soon after his arrival in Germany, World War I broke out, and he was interned as an enemy subject in various camps in Germany from October 1914 to June 1917. He was deputed to Germany for special studies in Systematic Botany and Plant Geography. He worked there under eminent and distinguished Professors such as A. Engler, A. Diels, R. Pilger, C. Correns, G. Lindau, H. Von Gutenberg and

others. In December 1919, he was awarded the Ph. D. degree of the Berlin University on submitting a thesis entitled "*Verbreitungsmittel der Xerophyten and sub-xerophyten deŝ Nordwestlichen Indiens und ihr Herkunft.*" The thesis was considered as a very laudable, 'Valde laudabile' by the examiners, Professor A. Engler and Professor G. Haberlandt. This very well-known paper of his deals with the mechanisms and means of dispersal and the distribution of xerophytes and sub-xerophytes of North-West India and traces their origin. It was duly published in a German Journal in 1920. From January 1920, he toured Europe extensively and visited Denmark, Norway, France, Spain and Italy. His visit to England proved very useful as he worked at the famous Herbarium at Kew and other places of botanical interest and visited Oxford and Cambridge. He also made several excursions to the Pyrenees and Sierra Nevada mountains in Spain as well as to the Mediterranean coast. The chief focus of his interest, wherever he went, was collection of rare and valuable plant material. His rich collection of herbarium specimens was later presented to the Calcutta University, and is one of the finest made by an individual. It rightly, therefore, became nucleus of plant collections of the Calcutta University.

As Ghosh Professor of Botany

He started his work as Ghosh Professor of Botany from July 1920 and took up the teaching of Systematic Botany and Plant Geography to Post-graduate students. He also gave important lectures on Gymnosperms and Genetics, fresh as he was from the traditions of Engler, Pilger and Correns. Senior students were immensely benefited by his guidance on botanical excursions which formed an annual feature of the Department's activities, and others by examining the material collected they got to study. He was at his best when at field work. His students even today remember this and express it so fondly. In 1921, he wanted to explore the Flora of Nepal, *Terra incognita* to most botanists then. The illustrious educationist of Banaras, the late Pandit Madan Mohan Malaviya, lent support to the idea and used his good offices to obtain the permission of His Highness, the Maharaja Sir Chandra Shamshere Jung Bahadur Rana to visit Nepal. Professor Agharkar along with Professor R. S. Inamdar and Professor N. K. Tiwary of Banaras Hindu University made a trip to Gosainthan in 1921, and to Muktinath, Damodarkund, the Valley of Kaligandaki in 1923. He is one of the few pioneer botanists who popularised Botany in that country.

It is now recognized by all that science has made phenomenal and rapid progress in course of th last fifty years and Botany is no exception to that. Professor Agharkar's motto in his twentyfive and odd years of service at the Calcutta University had been to impart advanced knowledge in various fields of Botany, and also to make original and critical conıributions to our knowledge of plants. It is admitted that the present growth and progress of Botany in its various aspects at the Botany Department of the Calcutta University are primarily due to the foresight and sagacity displayed by him. A unique feature of this Department of the Calcutta University is that researches on many different branches of Botany are carried out there and are recognized all the world over.

During his tenure of Professorship, the staff of the Department expanded to two full-time lecturers, four assistant lecturers and a host of Ghosh research scholars. The Department boasts today of having complete sets of many noteworthy botanical journals and reference works, besides several standard books.

Professor Agharkar had been a good morphologist. His interest in that branch led him to make critical observations on teratological phenomena in the plant kingdom. He recorded abnormalities of many phanerogams, especially those in the flowers of *Musa superba* and *Musa paradisiaca* sub-sp. *sapientum,* based on an examination of 2618 flowers. Such was his way of painstaking work before reporting.

He initiated embryological studies in *Carica papaya* and showed that the monoecious and dioecious forms of Papaya have similar development of embryo-sac. Cytological studies on the variation in the chromosome numbers in Musaceae were also conducted under his able guidance and on Solanaceae by P. N. Bhaduri, who today is one of the foremost cytologists of India.

Systematic studies on Algae and distribution of Charophyta in Bengal were carried out by himself and B. C Kundu.

Besides these he was always watchful of everything that happened to Botany in India. At one time it was proposed that the collections in the famous Sibpur Herbarium, Calcutta, containing rare and type specimens should be transferred to the Royal Botanic Gardens, Kew, London, for safe keeping. As soon as Professor Agharkar came to know of this, he was the first to indicate very pointedly what damage such a step would cause to the growth of Indian Botany and in his characteristic manner induced the authorities to consider the consequences of such a step. Ultimately the idea was abandoned. It is needless to emphasize the significance of this single act, which has had such a far reaching effect on the growth of Botany in India. Many of our herbaria now in charge of Botanial Survey of India, would certainly have been poorer for them, and the material they contain would not have been easily accessible for study to young Indian workers in this country.

In 1935, Professor Agharkar visited Europe again as a delegate to the Imperial Botanical Conference in London, the Sixth International Botanical Congress at Amsterdam, and the Third International Soil Science Congress at Oxford. The International Union of Biology at Amsterdam had him as a visitor in the same year.

During his stay abroad he made proposals to train young Indian botanists in systematic Botany at the Royal Botanical Gardens, Kew, and worked up a scheme for making the financial arrangements for creating studentships and fellowships for this purpose. As a result, two of the overseas scholarships from 1851 Exhibition Scholarships Fund were allotted to India.

It so happened, that at the Imperial Botanical Conference in London a proposal to train a number of young taxonomists from different countries in the British Commonwealth turned up for discussion. Each country was to depute one young botanist for training at Kew. He was to work as Botanical Assistant at Kew for his country for 2–3 years and return to the parent country later fully trained in taxonomy. This proposal was made mainly with respect to Australia

and Canada, as an Assistant for South Africa was already there. A similar provision for India was also there, from the funds made available by Government of India but no Indian was appointed to the post. Professor Agharkar immediately pointed out that though this post existed for India, it was generally occupied by some retired British scientist and India gets no benefit out of it. This should not have been so and some young Indian botanists should be trained from these funds. The Chairman of the Conference, Sir Arthur Hill, saw his point of view, but remarked that this suggestion should have come from the Government of India rather than from an individual. He also asked Professor Agharkar to follow it up, which he did. The result was that soon after, Shri K. N. Kaul, Director National Botanical Gardens, Lucknow, and later Dr D. N. Chatterjee, Director, Indian Botanical Gardens, Calcutta, were deputed by the Government of India to work in the post. But since Dr Chatterjee's return to India from Kew in 1949, the post itself has been abolished.

Another important matter pertaining to the training of Indian scientists which Professor Agharkar got straightened out was regarding the award of overseas scholarships of the London Exhibition of 1851. Indian princes and several Indians had contributed to the funds for these scholarships of 1851 Exhibition. No benefit, however, accrued to India which the other Dominions of British Empire were having. He, therefore, made a full study of the available reports of the Trustees of this fund and with the help of Sir Raghunath Paranjpye, who was then a member of the India Council at London, got the matter moving. He discovered that a scheme of scholarship to Indians was put up by the Trustees as far back as 1891 and £ 65,000 provided for it by His Majesty's Government, but no Indian scholar was ever appointed. Like the Botanical Assistant at Kew he followed up this matter also assiduously, and as a result, a series of Indian scientists started being selected for the award of Overseas Scholarships of 1851 Exhibition, London*. Dr H. J. Bhabha, Chairman, Atomic Energy Commission, Bombay, Dr K. R. Surange, Director, Birbal Sahni Institute of Paleobotany, Lucknow, and a few others were among the recipients of this scholarship which is still being continued. There are numerous examples of this kind indicating the tenacity of purpose characteristic of Professor Agharkar but these two will suffice as samples.

During the later part of his Professorship at Calcutta, facilities for researches in Cytogenetics, Mycology, Plant Physiology and Palaeobotany were created in the Department and important contributions to our knowledge of economically important crops such as rice, jute, mango, banana and to that of weeds like water hyacinth were made by the members of the Department.

A little before his retirement from the Ghosh Chair at the Calcutta University, he had started researches on the cytology of *Musa* and *Mangifera* financed by the I. C. A. R. He was also incharge of researches on the Polyporaceae and

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*In 1931, Dr Meghnad Saha had pointed that while India and the Indian princes had contributed largely to the funds of this exhibition, it was rather unfortunate that the benefit of these scholarships were not extended to Indian scientists. The matter was taken up by Dr S. P. Agharkar as the Secretary of ISCA.

Thelephoraceae financed by the same organisation. The Bengal Mill-Owners Association promoted under his guidance investigations on the diseases of long staple cotton in Bengal.

In 1923, he delivered the presidential address to the Indian Botanical Society at Lucknow on the position of our knowledge of aquatic flora of India. It shows the depth of his all-embracing knowledge of the floral composition of India and of a variety of ecological regions and environments. His masterly Review of the Progress of Botany in India was published by the Indian Science Congress Association in 1938. In 1943. he contributed substantially to a symposium on the present position of Botanical Research in India, held under the National Institute of Sciences, India. In this, he specially pointed out the then existing defects and lacunae in our work and researches in Botany in India and also suggested methods to remedy them. It is gratifying to note that most of his suggestions are being actively followed now.

In 1946, he retired from the Chair of Ghosh Professor of Botany. A gold medal was established in his name at the University of Calcutta. When he left Calcutta all realized what a gap was made by his going to Poona. Even after his retirement at Poona he actively participated in researches on the Plant Ecology of the Rajasthan desert taxonomy etc.

Honours and Distinctions

Apart from his numerous activities for the promotion of Botany in India in general and the Calcutta University in particular, he also took active interest in other academic bodies of the country. He was responsible for the radical revision of the syllabus for the Master's degree examination in Botany in Calcutta University and for the introduction of recent trends and advances in it. As a result of this, undergraduate courses were also revised and made up-to-date in 1941. Very often his extramural activities made heavy demands on his time. He was elected President of the Botany Section of the Indian Science Congress in 1924, his presidential address being on the Study of Plant Sociology. In the same year, due to the resignation of Sir C. V. Raman, he was elected Honorary General Secretary of the Indian Science Congress Association and he held this responsible and time-consuming office till January 1935. Even afterwards he continued to be a member of its Executive Committee till 1946. In 1934, he was elected Joint Organizing Secretary of the Academy Committee of the Indian Science Congress Association, and the Royal Asiatic Society of Bengal awarded him the Indian Science Congress medal in recognition of his meritorious services to that institution. He was elected a Foundation Fellow of INSA (formerly National Institute of Sciences of India) in 1935 and became its Honorary Secretary in the same year and held this office till 1945. It was mainly due to his untiring and ungrudging services in early years that the *National Institute* came to be recognised as a premier scientific body in India, advising Government on several scientific matters. During the Silver Jubilee Session of the Indian Science Congress held at Calcutta in 1938 he was elected Chairman of a Committee for a symposium on the "National Herbarium," a subject very dear to his heart. In the same year, he was appointed

Secretary of the Soil Conservation and Afforestation Committee of the National Planning Committee which submitted a valuable report on the subject.

He was one of the few persons who had a very intimate knowledge of, and association with, various scientific bodies in the country. He was President, Indian Botanical Society, 1934; Hon. Secretary, Indian Society of Soil Science 1935–40; President, Botanical Society of Bengal, 1940–45; President, Indian Ecological Society, 1940–45; Secretary, Biological Sciences, Royal Asiatic Society of Bengal, 1943–45; Vice-President, Royal Asiatic Society of Bengal, 1945–46; Vice-President, National Institute of Sciences of India, 1945–46. Since 1930, he was connected with the then Imperial Council of Agricultural Research as a member of its various Committees. He was also a member of the Agricultural Research Committee of the Indian Central Jute Committee. For several years, he was a member of Bengal Provincial Agricultural Research Committee and was on the Governing Body of Indian Research Fund Association, (now, Indian Council of Medical Research) from 1939 to 1942. He served as a member of the Nutrition Advisory Committee of the same institution for nearly 12 years.

He served on the Editorial Board of publications of the Indian Council of Agricultural Research, *Journal of the Indian Botanical Society* and the *Journal of the Department of Science,* Calcutta University. He was the Editorial Advisor to the publications of Indian Science News Association, *Current Science, Science and Culture* etc. Each one of these bodies would amply testify to his highly critical yet benevolent nature and to his vast knowledge and erudition.

As if all these multifarious activities were not enough for his talents and versatility, he also took keen interest in the development of scientific terminology in Indian languages, in the Brihan Maharashtra Parishad, etc. The Maharashtra Sahitya Parishad of Poona appointed him a member on the Terminology Commitee for Botany in Marathi which has published a useful report in this matter. His interest in cultural and social problems of the Maharashtrians settled in other provinces of India evoked considerable admiration from persons outside Maharashtra and he was elected President of the Brihan Maharashtra Parishad held at Delhi in 1943. He was also a President of the Board of Trustees of the Maharashtra Niwas at Calcutta, which is a useful institution for people going to Calcutta from elsewhere. But it has to be admitted here that all these efforts in developing scientific research and other activities in the country, left him little time to publish his own work. His students and disciples now scattered all over India and abroad, are holding coveted and responsible positions in Government, Universities and other academic and cultural bodies. Each one of them knows what they owe to him and bear the stamp he has put on their published work by his critical reading and suggestions.

On the eve of his retirement, the Calcutta University paid him a fitting tribute for his exceptional organising ability, great capacity for taking pains, his honesty of purpose and above all his national spirit and outlook.

After Retirement

Soon after his retirement from Calcutta, he returned to Bombay and resumed his academic and cultural activities there. He actively participated in the

post-graduate lectures of the Bombay University but later moved on to Poona, a city with better climatic conditions. On October 7, 1944, a meeting of educationists, scientists, agriculturists and industrialists of Poona was held under the chairmanship of the late Rt. Hon'ble Dr M. R. Jayakar which unanimously decided to start an organisation for the promotion of scientific research under the auspices of the Indian Law Society. A very modest beginning was made by creating the Maharashtra Science Institute, with Professor Agharkar as its Director. The Institution, now known as the Maharashtra Association for the Cultivation of Science, has departments of Botany, Entomology, Microbiology, Biochemistry, Mycology and Plant Pathology, and members of its staff are mostly drawn from retired scientists. Professor Agharkar also gave lectures to post-graduate students of Poona University for some time. The Indian Council of Agricultural Research sanctioned a grant of Rs. 50,000 to enable Professor Agharkar to continue investigations on the Cytogenetics of Mango and Banana, a scheme on which he was working earlier.

Professor Agharkar's selfless devotion to work induced spontaneous response from Shri H. P. Paranjpye and Shri E. B. Rajderkar who donated liberally and an Insect Breeding station was constructed attached to the main laboratory. But the biggest surprise came when Professor Agharkar joined the High Altitude Research Expedition to the Himalayas at the age of 65 and reached the starting station of the expedition two days in advance of the remaining party. He hesitated least to brave the hardships of mountaineering and proved to be the most enthusiatic member of the party.

Further Honours

At the instance of the Bombay Government, he undertook, a revision of the *Botany Volume* of the *Bombay Gazetteer*. The first part dealing with Medicinal Plants was published in 1953 and one on Timber and Woody Plants in 1957. Research students came to Poona and worked under his supervision and completed their theses for their doctorate degrees. In 1955, he was invited to deliver the Professor Albert Seward Memorial Lecture at the Birbal Sahni Institute of Paleobotany at Lucknow. After the sad demise of Professor S. L. Ajrekar and Professor N. V. Joshi, some departments of the Maharashtra Association for Cultivation of Science (M. A.C. S.) were adversely affected, but Dr G. B. Deodikar and Professor M. N. Kamat joined it voluntarily as honorary Cytogeneticist and Plant Pathologist respectively and expanded them again. For some time Dr L. B. Kajale, worked as Professor of Botany and contributed to the studies on the embryology of many plants, particularly of the oil palm, *Elaeis*. A new scheme on intergeneric and interspecific hybridization in wheats was started with the financial aid of the Indian Council of Agricultural Research, New Delhi. Work on the 'Band' disease of *Arecanut* and *Coconut* palms was continued with the financial assistance from the Central Committees for these crops.

As a token of their high regard and esteem to Professor Agharkar, professors, research workers, students and prominent citizens of Poona held a meeting on December 11, 1958 at the Law College premises to felicitate him on the

occasion of his 75th birthday. The meeting was presided over by Dr Sir Raghunath Paranjpye, the then Vice-Chancellor, University of Poona. He and several of the eminent personalities present eulogised the services Professor Agharkar had rendered to the cause of Botany in India, the organization of scientific activities and the dissemination of scientific knowledge, and an address was presented to him. In August 1956, Professor Agharkar had to undergo an operation for cancer. Though this and the subsequent convalescence were considerable drain on his health, his energy and enthusiasm remained unabated and he maintained constant contact with the working of the M. A. C. S. which was so dear to his heart, and other scientific activities. Up to the time of his rather sudden demise on September 2, 1960, Professor Agharkar was busy working, in collaboration with Sri A. K. Ghosh, Chief Palynologist to the Oil and Fuel Commission, Dehra Dun, on the floral elements of Bengal and the origin of the Bengal flora. Even on the day prior to his demise, Professor Agharkar, against medical advice, had been to the M. A. C. S. Laboratories, and made kind enquiries about the workers as well as the progress of the various research projects under way. It is beyond doubt that this institution founded and nurtured by him so carefully from its infancy, will grow from strength to strength and make a mark for itself as one of the foremost institutions in the country.

T. S. MAHABALL*

G. T. TONAPI

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T. S. Weech

THOMAS SHERLOCK WHEELER

(1899-1962)

Foundation Fellow 1935

Brith, Parentage and Childhood

Thomas Sherlock Wheeler was born in Dublin on April 30, 1899. He was the eldest of four brothers, his father being Martin Redmond Wheeler and his mother Brigid Frances Wheeler, formerly Sherlock. His family background is of some interest because it seems to have influenced him much in his later life. His father, Martin Wheeler, was an accountant by profession. Martin Wheeler's father, John Wheeler, died about the age of 30 leaving a widow and four children, of whom Martin was the eldest. They had, of course, a hard struggle but Martin, after finishing secondary school, became an accountant and worked in a firm of timber merchants well known in Dublin. In the meantime he attended the Royal University of Ireland at night time and eventually obtained an M.A. in Philosophy. In addition to his daytime job, he also taught in the Dublin Municipal School of Commerce at night, and in 1907, narrowly missed becoming the first holder of Chair of Commerce in University College, Dublin. Eventually, he became the Head of the Dublin Municipal School of Commerce. He was a scholarly man, tolerant of all opinions, with a good sense of humour, wrote fluently and was for some time a leading writer for Dublin newspapers. He was also a good speaker and lecturer.

Wheeler's maternal grandfather, Thomas Sherlock, was an interesting man. He was a poet, wrote music and novels, and for a long time was editor of a patriotic newspaper called "The Nation." He was a strong supporter of the Irish patriot Parnell, and wrote a rather adulatory, "Life of Parnell," which was published a year or so before Parnell's political career was ruined by his involvement in a divorce case. Thomas Sherlock served as a member of the Dublin Municipality for some years and eventually became President of the Court of Conscience which was a small debtors court. Actually the position was largely a political sinecure to which an income was attached. He was a hearty man, fond of his club and his drink and was a typical energetic Victorian who ruled his family with a rod of iron and had no patience with weakness or ill health.

Brigid Sherlock, Wheeler's mother, was unusual for a girl in those days because she finished her secondary education and later became a teacher of music. She was not much interested in domestic affairs, but was an omnivorous reader and ambitious for her children. She coached her son in such subjects as Latin, French and English; indeed she even went to the trouble of learning Latin to be able to help him. She encouraged him to do well in examinations. He felt that

her influence was most important in making him work at his books, a characteristic he had all his life. Her brothers and sister were of some interest also. One eventually became the City Manager of Dublin and gained some reputation as an able, cautious administrator; he was also a good linguist. A second brother, Lorcan Sherlock, who left school early, became a politician and Lord Mayor of Dublin, three times. He eventually became Sheriff of the City and was very successful as a director of several companies including the British Marconi Company. He was an outstanding public speaker and altogether a very capable man. Another brother, John Sherlock, to whom we shall return later, was a journalist and became editor of one of the leading Dublin newspapers. Eventually he found himself in the position where he felt that he could no longer follow the anti-labour policies of the proprietors of the paper and so he resigned; his resignation was not greeted with much joy by his wife who at the time had six children and was expecting a seventh. However, she agreed he had done the right thing. Later, he moved to London and got a position with the British House of Commons. He was a quiet scholarly man of many talents; he spoke several languages and wrote one or two novels. Brigid's only sister joined an Irish religious order—the Sisters of Charity. She turned out to be an excellent administrator with a flair for finance and eventually became the Bursar General of the Order.

Wheeler's own memoirs say that he grew up in a bookish home—both his parents read widely and there were many books in the house which he read. He had no great interest in sports. He felt he was influenced by his father's humorous tolerant outlook and his devotion to work and also hy his mother's interest in his educational progress. Within the family, as can be imagined, there was a fair amount of political discussion; the political feeling in the family was rather moderate; they were basically so-called Home Rulers who believed in some self-Government for Ireland but not in a complete break with Britain. In that atomosphere, he learned the importance of being able to make a speech and of knowing how to persuade people.

Education

Wheeler received his secondary schooling from 1909 to 1916, in the O'Connell School which was a large school in Dublin run by the Christian Brothers, a place his father had attended before him. The teachers in the school, as was common in the Ireland of that day, adopted the educational policy that boys could be taught to learn only by beating. He himself commented in some notes, that he was well beaten until he was 15, but thought it encouraged him to work and did him no harm. However, it is not clear that he really believed this and often used to recall that, when he was about 14, the French teacher insisted every day during the school year on seeing his homework before classes started and proceeded to give him six blows on each hand with a leather strap because of the poor writing. Those who knew him in later years would realize that this type of treatment did nothing for his writing. He remembered three teachers : two were Christian Brothers, one gave him an interest in physics and the other in mathematics and presumably this was part of the reason that he eventually ended

up as a scientist; the third was his English teacher who was a poet with some reputation and gave Wheeler a command over words. This teacher encouraged him to read McAulay's essay on Warren Hastings which helped him develop an interest in India, that continued for the rest of his life. In the final government examination in 1916, Wheeler stood first in Ireland in English, physics and mathematical and science groups. He was awarded scholarships tenable at University College, Dublin and in the Royal College of Science for Ireland, and he decided to take the latter one. Later, that College was merged with University College, Dublin, and the Chemistry Department, which he was later to head, was located in the former building of the College of Science.

The course in the College of Science was four years to an Associateship of the Royal College of Science of Ireland. Wheeler felt especially influenced by three of his teachers, one in physics, one in chemistry and one in mathematics. The mathematician, seeing that he had an interest in mathematics, gave him extra lectures; these were the basis of the good mathematical knowledge that was so useful to him in later years. Simultaneously with taking the Associateship of the Royal College of Science in Ireland, he successfully sat as an external student for the London B.Sc. degree. His years at college were turbulent ones for Ireland; the 1916 Rebellion had taken place just before he went to college and from 1919 until the end of 1921 the War of Independence raged. At college he became a member of the Irish Volunteers and (as such) attended classes in which instructions were given on chemical warfare and such things as how to cut down telephone wires. These classes were given in houses where dances were being held in the front room to give the building an innocuous appearance. Wheeler was never involved in any fighting and all his life had a horror of violence.

Professional Career

Before the 'Troubles' had reached their peak, Wheeler left Ireland in the summer of 1920 to take up his first post which was at the Royal Technical College of Glasgow, later Strathclyde University, as a demonstrator in Chemistry and spent one year there. During that period, he began to show his originality of mind. For example, he had some novel ideas about the teaching of practical organic chemistry and this resulted in a collaboration with two of the more senior staff members (Cumming and Hopper) in the famous book *Systematic Organic Chemistry,* which was for many years a standard laboratory text. He also became interested in the problem of devising a rational nomenclature for organic chemistry which will be discussed below. Shortly before Wheeler left for Glasgow his father was diagnosed as having terminal abdominal sarcoma, and Wheeler frequently came back to Dublin for weekends during his father's final illness. In June 1921, Martin Wheeler died at a comparatively early age.* After his

*This resulted, or so the family thinks, in a tragic sequel two years later when Wheeler's brother, Desmond, (the second boy in the family) died of what appeared to be leukemia, probably induced by exposure to radiation during his father's illness; Desmond regularly collected radon needles from a local hospital and deposited them on his father's abdomen for treatment; all this was done with no protection or even precautions.

father's death, Wheeler had to assume the heavy burden of being the main financial support for his mother, a burden which continued for 30 years.

In 1921, he moved from Glasgow to the Royal Naval Cordite Factory in Holton Heath as a research investigator attached tc the Department of Scientific and Industrial Research. While there, he worked under E. W. Blair on the oxidation of hydrocarbons at high temperatures. The studies were carried out on a semitechnical scale, as well as in the laboratory. This was a fruitful period and in 1924, he was granted an external Ph.D. degree from London University on the basis of his work at Holton Heath. In 1923, he was appointed to a post on the factory staff but shortly afterwards moved from Dorset to work at Woolwich Arsenal as a research chemist.

This move was not a promotion; it involved a decrease in salary but was made for a personal reason. Wheeler wanted to marry his cousin, Una Brigid Sherlock, a daughter of John Sherlock mentioned above and, in his usual thorough way, decided the best way to press his suit was to be on the spot; he eventually married Una Sherlock in March 1926. The marriage was a very happy one. He himself always said it was the best thing he had ever done. In this later years, he displayed an almost missionary zeal in encouraging his students to get married; nothing made him more impatient than someone hesitating over getting married. His wife provided him with a great deal of support and help over the years, and much of his success was due to her influence. Indeed there is a charming description by Dr B. G. Ferreira, a former student, of an incident as he left India in 1960, which illustrates this point.*

At Woolwich, Wheeler worked on the synthesis of high explosives, gelatinisers and propellants and then on the experimental detonation plant. Much of this work was dangerous and one project was discontinued after he left because his successor in the work lost an eye in a laboratory accident.† Security restrictions prevented his publishing much of the work he did at Woolwich; only 1 patent and 1 paper resulted from those years. While at Woolwich, Wheeler did a lot of extra work, presumably to make money. Not only was he married, but John Sherlock had died in December 1925 and so he was helping financially his mother-in-law as well as his mother. The extra work included patent searches and abstracting. He also translated two books from German and was a co-author with Reilly and Rae of the well-known *Physicochemical Methods.*

His next post during 1928–31, was of a senior research chemist in the Winnington (Cheshire) Research Laboratories of the firm of Bruner-Mond which shortly before his arrival had become part of Imperial Chemical Industries. Wheeler was in charge of a Gas Reaction Group, which from small beginnings had grown to 20 scientists (chemists, physicists and engineers) by the time he left ICI. He was responsible for the development of a high temperature (1000° or higher)

*"Dr Wheeler was on the point of emplaning without raising his arm for the final farewell to those who had gathered to bid him goodbye. Mrs Wheeler immediately sized up the situation, and true to feminine tradition, apprised him of the lapse by nudging his shoulders. Dr Wheeler immediately responded by waving his arm high up for the last affectionate and enthusiastic farewell."

†The work at Holton Heath was also very dangerous; Wheeler's former supervisor, E. W. Blair, was killed with eight others in a nitroglycerine explosion in 1931.

high space velocity method for carrying out gas reactions. The work led to the development of a number of new processes which were tried in the laboratory and on a semi-technical scale. This was a very successful period of his life and some 17 patents and several papers resulted. When the depression came, ICI stopped all research though initially they did not dismiss any of their scientists. Wheeler could not stay idle and so started theoretical studies, which resulted in several papers. He also requested the company to put him on a course for plant managers. After taking this course, he constructed a complete flow diagram of the Solvay plant, one of the main processes in the Winnington Works.

In 1931, he applied for and obtained the position of Principal and Professor of Organic Chemistry at what was then called The Royal Institute of Science of Bombay. A major factor in his getting the position was the industrial experience he had gained both at Holton Heath and at ICI, because one of the duties of the new Principal was to set up the Department of Chemical Technology in the University of Bombay. He arrived in India in October 1931 and left almost 7 years afterwards. But in this short space of time, he achieved an enormous amount. The Institute had opened in 1920. The first two Principals, Drs Fox and Meldrum, had both encouraged research to some extent but Wheeler's great achievement was that he founded a really substantial school of research at the Royal Institute. For example, the number of research students in organic chemistry doubled (25 to 50) while he was at the Institute and his organic staff eventually included Professors R. C. Shah, N. W. Hirwe and D. R. Nadkarni. Wheeler was always proud of the fact that he had persuaded Professor Venkataraman to come to the Institute as a staff member in the Department of Chemical Technology. When he left India, the Institute had a staff of 60, 120 graduate students,120 full-time undergraduates, and some 350 part-time students (e.g. arts students taking science subjects).

The research Wheeler did in India covered a myriad of fields. Much of it was theoretical (including a theory of liquids), and grew out of his work in ICI. He also did some applied work. However, as the years went on, his interest in organic chemistry became dominant. They started with studies of the kinetics of the benzoin reaction and other, mainly heterogeneous, reactions. Later, he started his work in flavones, which became his principal research interest when he resumed academic work in Dublin in 1945. While in India, he directed the research of 24 M.Sc. and 5 Ph.D. students. (The latter degree was only established some years after he had come to Bombay). The breadth of his interests is shown by the fact that apart from being a Fellow of the Institute of Chemistry, he was also elected a Fellow of the Institute of Physics (1932) and as a member of the Institute of Chemical Engineers (1933).

In the long vacation of 1932, Wheeler prepared plans for the foundation of the Department of Chemical Technology in the University of Bombay, which was originally lodged in the Institute of Science. Wheeler served as the Vice-Chairman of the Board controlling the Department, (the Vice-Chancellor being the *ex-officio* Chairman). The first Director of the Department was Dr R. Foster. Later, Professor Venkataraman took over and the Department moved to new buildings in Matunga, where the Department has since flourished

and become an enormous operation on its own.

Wheeler played a full part in the affairs of the University of Bombay. He was Dean of the Faculty of Science (1934–36), member of the Senate, the Syndicate, and of a large number of standing and adhoc Committees. The last included such different areas as an investigation of the leakage of examination papers and the revision of the University Act.

Outside the University, he was general adviser on scientific matters to the Government of Bombay. Lord Brabourne. the Governor for most of his years in Bombay had an especially high regard for Wheeler's abilities. He represented the Government on the Board of the Prince of Wales Museum, and was particularly involved with supervising the building of a new wing. He was also concerned with the control of the Central Technical Institute and was a member of the bodies supervising all Technical Schools and controlling Agricultural Research in the Presidency of Bombay. He served as Consultant to the Punjab University and the University of Patna.

He spent a month as guest of Sir C. V. Raman in the Indian Institute of Science in Bangalore. Raman was one of the many distinguished Indians (e.g., Sir Narayan Chandavarker (the Vice-Chancellor at Bombay), and Mr K. M. Munshi, a distinguished Congress politician whom he enjoyed knowing. Another of his pleasant memories was the visit to Bombay of a group of distinguished British scientists (e.g., Jeans, Tizzard and Aston), who were visiting India to attend the Silver Jubilee Session of the Indian Science Congress.

In 1936, Wheeler became a Foundation Fellow of the National Institute of Sciences of India (now known as the Indian National Science Academy) and later served as Vice-President of the Institute. This honour gave him particular pleasure. He was also President Elect for 1939, of the Chemistry Section of the Indian Science Congress but had to leave India before he took up that office. He was a member of the Council of the Indian Chemical Society, and an Assistant Editor of its journal and of *'Current Science'*. He was a member and Vice-President of the Indian Academy of Sciences and delivered the Inaugural address at one of its meetings.

The period he spent in India was very productive and happy for Wheeler, which he enjoyed greatly. His departure from India in 1938 was primarily precipitated by his wife's ill health—it had become clear that she could no longer stay in India during the hot weather. Also, his son, Desmond, had been in school in England since 1936 and presumably his second child, Brenda, would have to leave as well. When he left, there was much regret on the part of many Indians who had come to respect and like him very much. Yet his success in India is perhaps more noteworthy when one considers the circumstances under which he arrived in Bombay. At that time, there were several competent members of the staff of the Institute, some older than he was, and there were naturally some strong feelings that the time had come for an Indian to become the Principal. Although the primary reasons for Wheeler's appointment was his experience in chemical technology, his position was very difficult and it says something for his abilities and also the tolerance of Indians, that by the time he left Bombay he had established himself with his colleagues in such a strong way. Of course, as an

Irishman he understood what it was for India to be run by a foreign government and he sympathised with the Indian national aspirations.* To see how Indians felt about Wheeler one only has to read the Golden Jubilee Volume of the Institute of Science, where many former students and associates speak of him as Principal, in the warmest terms. They were all struck by his youth, (he was only 32 when he arrived in India), his energy, his hard work, his encouragement of research and his strict discipline although they found that in practice he was very kindly and would do all he could to help a student in trouble. He was also concerned about the well-being of even the most lowly members of his staff.** All these things made an enormous impression that lasted many years after he left.† His death in 1962 was announced on All India Radio and even today there are many people in India who cherish his memory. This is particularly true of his former students.

Wheeler left India in September 1938 and back in Ireland, took up the position of State Chemist. He realized that this was not going to be as demanding a job as the one in Bombay, nor would it capture his interest to the same extent, and so as he passed through London on his way to Ireland, he asked a fellow Irishman, Professor F. G. Donnan, what area of chemistry was the upcoming one. Donnan suggested quantum mechanics. Wheeler bought himself a copy of the famous book by Pauling and Wilson and started to study it. In Dublin, he took a course in wave mechanics from Schrödinger, who was then Director of the School of Theoretical Physics of the Institute of Advanced Studies in Dublin and later Wheeler published two papers in this area. In 1943, he was appointed a member of the Governing Board of the School and held the position for the rest of his life.‡

Wheeler's new position in the State Laboratory was not an easy one. Since Ireland had become independent in 1922, there had been three State Chemists; the first two were part-time and the third had had a nervous breakdown a year before. As a result, several administrative problems in the laboratory had to be handled firmly by Wheeler. But as in India, he once again won the loyalty and affection of his staff, particularly by his constant advocacy to improve their conditions. When he left, the Laboratory staff presented him with a matched set of golf clubs, a gift of which he was especially proud.

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*In the 1940s, an Indian acquaintance was shocked, while in Dublin to be asked by a senior government official about Wheeler's attitude to the Indian National Movement. He immediately said that Wheeler was sympathetic and subsequently phoned the family to tell them of the conversation.

**At one point he noticed that the peons looked very underweight and was shocked when he discovered their average weight was 40 kg. He promptly instituted free milk for them and paid half the cost himself. The other half was provided by donations from the staff. The peons weights all went up. Then there was a complaint that the milk was being watered. This was found to be true; the contractor was warned and the watering stopped.

†In 1971, Dr T. N. Mehta, a former staff member in the Department of Chemical Technology during the 1930s, was visiting a nephew in Lincoln, Nebraska, and called on DMSW to say how kind and helpful Wheeler had been to him at a critical period of his career.

‡Wheeler found Schrödinger a most interesting person and later received from Mrs Schrödinger a written account of the circumstances surrounding Schrödinger's departure from Austria to Dublin after the Nazis took over Austria in 1938.

The main duties of the laboratory had to do with the testing of samples largely for the customs and sometimes for the police. Some cases had interesting and amusing facets. This, of course, was a completely new area of endeavour for Wheeler. However, the fear that he might not have enough to do did not in fact turn out to be true because of the Second World War. In 1941, he was aksed by the Prime Minister, Mr De Valera, if he would act as one of a group of five scientists who were to be the directors of what was called the Emergency Scientific Research Bureau. The duty of this Bureau was to alleviate various wartime shortages. As far as chemistry was concerned, this involved setting up small plants, for example, for the production of formaldehyde, and potassium chlorate.* The Bureau completed many successful projects. In 1942 or 1943, Wheeler sought an interview with the Prime Minister to suggest that as tuberculosis was a tremendous scourage in Ireland, research should be initiated into the chemotherapy of tuberculosis. The Government accepted the suggestion, and under the auspices of the Medical Research Council of Ireland set up a research group on the chemotherapy of tuberculosis. Naturally, Wheeler was a member of the group and at his suggestion, Dr V. C. Barry, an able organic chemist, was appointed as the Director of the Group. Dr Barry and his collaborators were responsible for much distinguished work in this area. The laboratory continues to operate, but in view of the conquest of tuberculosis, it has changed its emphasis to cancer problems.

During the War, he served as a member of the Local Security Force which was, in effect, an auxiliary police force, set up in case Ireland was invaded or some other type of emergency arose. Those in charge of the local force realized very quickly that Wheeler's abilities were not best used in patrolling country roads at night. He was transferred to a staff job and this was in fact where he ended up.

In 1945, when the Chair of Chemistry at University College, Dublin, fell vacant, the College authorities recognized that Wheeler was the logical candidate and they asked him to apply. At that time posts in University College were filled by a series of elections by several bodies. They included the Faculty of Science in the College and other faculties in which chemistry was taught, the Academic Council and the Governing Body of the College and finally the Senate of the University. Some 200 people were involved in this election although the final decision lay with the 25 or 30 members of the Senate. The custom at that time was that a candidate applying for a job spoke to everyone involved in his election. Wheeler felt that this was not a way in which university posts ought to be filled and he announced straight away that he would not do any personal canvassing. Nevertheless, in spite of this break with tradition, he was elected overwhelmingly to the position and assumed it in September 1945.

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*During this work he became friendly with Major V. De Valera the Prime Minister's son. Major De Valera was a man of many parts. He had a B.Sc. in physics. He was a practising barrister before the war, then joined the Army and later became the publisher of a newspaper and a member of the Dail (Irish Parliament). During the War, he and Wheeler worked together on a number of projects including the rather risky one of dismantling hand grenades. He married one of Wheeler's staff in the State Laboratory and after his wife died young, did part-time work again on the chlorate project, eventually receiving a Ph.D. in chemistry.

Wheeler's work during the War had gained the attention of not only Mr De Valera but also of several of his ministers.* About the time he was appointed to the University College, Dublin, the government asked him to serve on the boards of 2 state companies; the Turf Development Board and Ceimici Teoranta (Chemicals Limited). The Turf Development Board, later to become Board na Mona (Turf Board), was responsible for large-scale production of peat in Ireland. This fuel has become most important and is widely used in the production of electricity. Ceimici Teoranta was originally concerned with production of industrial alcohol although in later years it expanded its operations to starch. Wheeler also devoted much time at a later stage, in considering the possibility of making ammonium nitrate in Ireland.

Some months after Wheeler took up the position at University College, the Minister of Industry and Commerce asked him to accept the position of Director of a new Institute of Industrial Research and Standards. He decided that he preferred to stay in academic life and turned the offer down. However, he served on both the Industrial Research Committee and the Irish Standards Committee which were both concerned with the operations of the new Institute.

The confidence De Valera's government showed in Wheeler was in no sense a political matter. Wheeler's political views were moderate and despite his admiration for Mr De Valera and his high regard for many of his ministers, he did not support the Government politically. Nevertheless, they valued his advice. He liked his colleagues on the Boards but was always somewhat amused by the difference between his background and theirs. For example, he was the only member of Board na Mona who had not fought on De Valera's side in the Civil War of 1922–23. He once embarrassed his colleagues on the Board by announcing to a group of English visitors that he was the only member of the Board who had never served time in jail. A member of the Board rejoined coldly that only political offences were involved.

The coalition government which ruled Ireland during 1948–51 also showed its appreciation of Wheeler's abilities. At that period there was a suggestion that Ireland with support from Marshall aid should set up a new University College of Agriculture in which the functions of teaching, service and research would be combined in one institution. In Ireland, the so-called service or extension functions were part of a government department rather than of a College. The Government accepted the plan in 1950 and appointed Wheeler, President-Designate. Early in 1951, he spent two months in the United States inspecting the production of fertilisers, and schools of agriculture. He spent one month at the University of Vermont, where the Dean of the Faculty of Agriculture was the American representative for Marshall aid in Dublin. This was his first trip to the U.S. He enjoyed it thoroughly and was keen to go back. The idea of setting up an

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*One amusing incident involved Wheeler being asked by the Minister of Coordination of Defensive Measures to attend the testing of a new sort of gun. The tests went on a for long time, well past Wheeler's normal mealtime. The Minister suggested that the gun should be fired in a certain way : Wheeler who wanted his meal badly snapped, '*This is mere fooling around.*' The Minister looked startled but said at once, 'We will stop and take Dr Wheeler to dinner.'

Agricultural College was a challenge which he would have enjoyed. He used to say on many occasions, "he travels farthest who knows not where he travels" a quotation from Oliver Cromwell, a person quite unlike Wheeler.* However, later in 1951 there was another election, De Valera returned to power, and the idea of a College of Agriculture was abandoned.

When Wheeler took over the Department in University College, Dublin, it was going through a difficult time. The staff was small. There were, besides Wheeler himself, three organic chemists and a physical chemist (who had in fact been trained originally as an organic chemist). All were older than Wheeler and two had been his teachers. Chemistry had gone through a great change in the years from 1935 to 1945 and Wheeler felt the need to modernize the Department. Rightaway he started teaching inorganic chemistry courses, and in fact over the years taught chemistry at every level at least once, to find out what was going on. He had strong views about how chemists should be educated (*see* page 44) and naturally, in spite of the great conservatism of the staff, made many changes. Physical chemistry was stressed more in the first year; new courses were introduced. Wheeler himself taught quantum mechanics and stereochemistry. He stressed the importance of teaching electronic theory of organic mechanisms. He expanded the staff—it was about 20 when he died—and was particularly concerned with developing the teaching of modern physical and inorganic chemistry. He also had the problem of trying to equip the department in a modern way. Soon there were complaints that the Chemistry Department was spending more money in one year than the Botany Department had spent in the 40 years since establishment of UCD. Before he had been appointed, plans had been made to establish a Diploma in Chemical Technology in UCD, and so after his arrival he repeated (though on a smaller scale) what he had done 15 years before in India.

The only research he did during his years in the State Laboratory was his work on theoretical chemistry which to him was essentially a recreation. At UCD, he restarted his flavone work and in the remaining seventeen years of his life he built up UCD into a school with an international reputation in flavone chemistry. After his death that tradition was carried on by his successor, Professor Philbin, and several of his former students. He also encouraged the young physical and inorganic chemists to initiate research, so that the reputation of the Department would not rest only on organic chemistry.

The years Wheeler spent in UCD coincided with a rapid increase in the number of students, and soon there was a shortage of space in the Department. As a stop gap an additional floor was inserted in a laboratory with a very high ceiling. But clearly more lasting measures were necessary. Needless to say, Wheeler made a strong case for his department. Eventually, it was agreed that a building for chemistry should be put up on a new campus about 3½ miles from the centre of Dublin. Wheeler worked hard on the plans and the building started in 1961. However, Wheeler never saw the fruits of his labours, for the Department only moved

*Wheeler's other favourite quotation was from Longfellow : "*The heights by great men sought and kept were not attained by sudden flight. For they, while their companions slept, were toiling upward in the night.*"

two years after his death. Wheeler's contributions to the UCD Chemistry Department were the most notable achievement of his busy and productive life: in 17 years he developed what was a small department into a vigorous modern laboratory.

As in Bombay, Wheeler played in Dublin a full part in University affairs. He was Dean of the Faculty of Science from 1951 to his death, a member of the Governing Body of the College, and was a member of several important committees of that Body, including the key Finance Committee, and also served on the Senate of the University. He was outspoken and did not hesitate to speak his mind even when it happened to be a minority view. At an investigation conducted by two judges of the High Court on the legality of certain appointments in the University, Wheeler's forthright evidence received especial commendation.

Wheeler also was much involved with chemical organizations. He served for many years as a member of the Council and the Committee for Publications of the Chemical Society. He was on the Council of the Royal Institute of Chemistry and was its Vice-President. When he arrived in Ireland, Irish chemists had a small organization called the Irish Chemical Association. Wheeler served as President of that association for 2 years and was responsible for reorganising it as a chartered body, the Institute of Chemistry of Ireland. He was responsible for organizing the International Symposium on γ-Pyrones in Dublin in 1955 (attended by Professors Venkataraman and Seshadri), and for the meeting of the British Association for the Advancement of Science held at Dublin in 1957. He also had a part in planning a meeting on fungal metabolites held in Dublin after his death. He represented Ireland on the organization for the European Economic Cooperation Committee on Scientific and Technical Personnel and in 1959 wrote a report on the scientific personnel problems in the United Kingdom.

After Wheeler's first trip to the U.S. in 1951, he was anxious to go back to that country. In early 1958, he and his wife spent 2 months visiting a number of university chemistry departments including most of the best ones in the U.S. He enjoyed this experience, not only the part that related to chemistry but also the novelty of travelling enormous distances in a variety of ways (air, train and bus). In 1960, he and his wife attended the first IUPAC meeting on Natural Products in Australia. En route, he visited India for the first time since he left in 1938 and thoroughly enjoyed his return to the Institute* and many other laboratories and met several old friends. From India they went to Hong Kong, Japan, Taiwan, the Phillipines, Australia, New Zealand, and Hawaii. They then spent 2 weeks on a trip to Mexico with their children and daughter-in-law. This was followed by another tour lasting 3 months across the U.S. and they returned to Ireland on December 31 after an absence of 6 months. All told, Wheeler lectured in over 100 institutions in some 13 countries besides Ireland. The last meeting he attended was the IUPAC Conference on Natural Products in Prague in 1962.

His Broad Interests

Although Wheeler had no hobby, he was a person of broad interests. He enjoyed travelling and seeing new places and, aside from his world tour and his trips to

*A former student, Dr B. F. Ferreira, has written an account of that visit.

the U.S. had travelled widely in both India and Europe. He read extensively, being particularly interested in history and archaeology (hence his especial delight in visiting Greece). He had a legalistic sort of mind and liked reading about law cases that involved nice legal points. He enjoyed listening to classical music especially opera, Mozart being his favourite composer. In a relaxed mood he was excellent company with a good sense of humour. He never had much interest in games, golf being his main recreation in later years, though he played and enjoyed tennis till he pulled a muscle in his leg in 1942. During the War, when private cars were off the roads he rode a bicycle everywhere doing at least 16 miles a day, though after the War he used his car all the time. He liked to go for walks and drives in the country and also played some bridge.

Personal Qualities

His most notable personal qualities were his integrity, intelligence and imagination. He was always full of new ideas; it has been well said that he had a passion for progress. He worked very hard, had great drive and showed an enormous zest for life. He was always generous and sympathetic to those in trouble both in time and money. Like his father he was tolerant of others' opinions. This is best illustrated by his religious beliefs. He was a committed Catholic but his tolerant attitude to other beliefs was characteristic of the Catholic Church of the post rather than the pre-Vatican Council period. In this, as in other matters, he was far ahead of his time.

Wheeler enjoyed excitement; he liked to work in his office with perhaps two people talking to him while he simultaneously talked over the phone. Interviewing people who came to see him in his office, he did not waste time with non-business matters and there are several amusing stories of people who found themselves outside the office before they had mentioned all the business items they wished to cover. Although he had many friends, he had few really close ones; in later years, there were 3 or 4 whose company he especially enjoyed.

Family

Beside his wife, Una, who still lives in Dublin, Wheeler had three children: the eldest Desmond did his Ph.D. under his father, spent some time on the staff of Trinity College, Dublin and two years in Woodward's laboratory in Harvard. Apart from 2 years at the University of South Carolina he has been on the staff of the University of Nebraska since 1958. He works on the synthesis of natural products and photo-chemistry. He has been a Professor since 1966 and obtained his D.Sc. from the National University of Ireland in 1977. His wife Margaret has a Ph.D. and has worked extensively with her husband. In 1978, the Wheelers spent a month in India visiting a variety of chemical laboratories including the Institute of Science.

The elder daughter, Brenda, is also a chemist with an M.Sc. from Trinity College, Dublin. She spent two years in the Worcester Foundation for Experimental Biology in Worcester, Mass., returned to Ireland in 1961 and joined the staff of

the Irish Agricultural Research Institute. She works near Dublin and has become an expert on the composition of animal feeds.

The younger daughter, Thomasina, was born after Wheeler took up his appointment at UCD. She decided that a father, brother, sister and sister-in-law were more than enough chemists in the family and so did a B.A. and works as an administator in the Medical School office in University College. However, her background was too much for her; in May 1975, while attending the dinner being held for the Wheeler Memorial Lecture given by Professor Battersby, she met Dr W. E. Waghorne a physical chemist on the staff at UCD. They were married in January 1977. Two of Wheeler's brothers survived him; the elder is a retired bank manager; the younger was a prominent chartered accountant who died in 1976.

Last Day

Wheeler died on December 13, 1962. It was a not untypical day; in the morning he attended a meeting at which the future status of Pharmacy in the University was discussed and he persuaded his colleagues to organize affairs as the pharmacists wanted. He then had lunch with the Chairman of the Committee on Industrial Research and that afternoon was to drive to Cork (170 miles) to give a talk on 'Billiard Balls and Hard Water' (*see* page 46). However, on his return from the lunch to the College he collapsed, with a massive coronary infarction, was taken to a hospital, and, in spite of strenuous efforts to resuscitate him, was dead 2 hours later. At least five hundred people attended his funeral; they included Mr De Valera (then President of Ireland), and the Prime Minister and Chief Justice of Ireland. Afterwards his friends set up a Memorial Lectureship; it was fitting that his close friend Professor C. K. Ingold gave the first Wheeler Lecture; he has been followed by a distinguished group of chemists including several Nobel laureates.

Scientific Work

Wheeler's list of publications is a remarkable one, not just for its length, with over 200 papers, but through the breadth of interests it reveals : there are papers on theoretical calculations including the theory of liquids, organic chemistry including synthetic and mechanistic work, applied work relating to the development of industrial processes, various analytical studies, discussions of the education of chemists both at the University and secondary school levels, and work on the lives of various Irish chemists. The record is even more impressive when one remembers that there were two periods, the years at Woolwich (1923–28), and those in the State Laboratory (1938–45), when Wheeler had little opportunity to do publishable work. The years in India were particularly fruitful; all told they account for about 30% of his publications; about 35% of the organic chemistry was done there and some 70% of his work in physical chemistry and physics. The diversity of the subjects Wheeler covered makes it impossible to discuss his work chronologically; instead it will be described under several headings, applied chemistry and related subjects, physical chemistry and physics, physical organic

chemistry, synthetic organic chemistry including flavonoids, historical studies, educational work, and finally several miscellaneous topics.

Applied Chemistry

Wheeler's degree was in applied chemistry and so it is not surprising that his first substantial body of research work was a series of thirteen papers in applied studies. These were published in collaboration with E. W. Blair with whom he worked in Holton Heath during the years 1921–23. This is the only work Wheeler published in which he was not the senior author, and it formed the basis of his Ph.D. degree.

The object of the research was to develop a process for the industrial production of formaldehyde by the oxidation of hydrocarbons. The first five papers deal with the reaction of oxygen with ethylene, methane, coal gas, (a mixture of ethylene and methane with the idea that coal gas could be used as a feed stock for the process) and hexane. The reactions were done at high temperatures, about 700°, and as formaldehyde is unstable at these temperatures, it was critical that the times of reaction should be very short, a matter of 1–2 seconds. The complicated mixtures of products were analysed, and it was possible to learn something of the pathways which led to formaldehyde. For example, the conversion of ethylene to formaldehyde went through acetaldehyde. Three papers were devoted to studies using ozone and finally there was a note on an interesting reaction of hexane and bromide. Several experimental techniques were also developed for the work. The final paper from Holton Heath discussed theoretical and experimental studies on the separation of hydrogen and carbon dioxide formed in the production of *n*-butyl alcohol and acetone by the fermentation of carbohydrates.

Only one publication, a patent, seems to have resulted from his laboratory work at Woolwich. However, the period in Winnington was very fruitful and resulted in a series of patents, followed by a number of papers; an excellent account of the work is in the issue of the *Journal of the Indian Chemical Society* devoted to commemorating the 70th birthday of Sir Prafulla Chandra Ray. The object of the work was to find was of using methane. The technique that was eventually developed was to run reactions for very short times at high temperatures by passing gases rapidly through a reaction chamber. Thus methane and ammonia reacted during .01 of a minute at 1350° to give almost complete conversion to hydrogen cyanide. The decomposition of methane to carbon and hydrogen at these temperatures was prevented by carrying out the reactions in silica vessels.* Similarly carbon disulphide was made by keeping methane and sulphur at 1,400° for .005 minute; hydrogen or hydrogen sulphide was the by-product depending on the ratio of methane to sulphur. Heating methane to 1,200°–1,240° gave a mixture of aromatic hydrocarbons. The studies were then extended to exothermic reactions. Hydrogen and chlorine reacted efficiently and the method could be used to make hydrochloric acid directly. When methane was introduced into

*Various alloys also inhibit the decomposition and Wheeler suggested later that materials used in this work should not have many loosely bound electrons.

the zone of combination of hydrogen and chlorine, acetylene was formed. Apparently, the exothermic nature of the reaction of the hydrogen and chlorine was sufficient to supply the energy necessary to convert methane into acetylene. Methyl chloride was formed from methane and chlorine at 900° with reaction periods of 1/10,000 of a minute. Chlorination of propane at 700° for 1/1,000 of a minute gave propyl chlorides in 88% yield. The chlorination of methyl chloride to methylene chloride, and of benzene and toluene was also investigated. At 500° chlorine and toluene gave a mixture of benzal and benzyl chlorides; in the absence of carriers there is little attack on the ring. Benzene, however, is chlorinated at 450° for .02 of a minute to mono- and di- chlorobenzenes. It should be noted that this is a substitution reaction taking place in the absence of a carrier. As a glance at the list of patents will reveal, the process was used to obtain other products beyond the ones discussed here.

The experimental work done in Winnington, led Wheeler to carry out some theoretical investigations of the thermal decomposition of methane. Working from experimental results in the literature, he was able to show that the kinetics of the reaction fitted several empirical equations and was able to deduce a tentative mechanism for the decomposition of methane in the presence of copper oxide.

After Wheeler went to India, his major interests were naturally enough no longer in applied research. However, both in India and later in Ireland, he was involved in some applied research with the object of helping to develop local industries. For example, in collaboration with Acharya, he investigated thoroughly the published syntheses of camphor and terpineol with a view to seeing if these could be run on a large scale in India, and devised several improvements. The same authors also published a paper showing that the cleansing power of a soap is related to its absorption on a fibre. Two more general papers also resulted from his time in India. The first, circulated privately, describes the importance of science in the textile industry; in it there is some stress on the importance of cheap sources of energy in a process, a problem still with us. The second paper describes approaches to applied chemical research.

Wheeler initiated several applied projects in Ireland. One was a comprehensive analysis of fuel oils by careful fractional distillation. This was a very difficult problem as it was undertaken in the days before gas chromatography was available and it did not result in a publication. The second problem involved the isolation of estrogen from urine. Ireland has a large race horse industry and Wheeler hoped that a workable method could be developed for isolating estrogens. The Chemistry Department bought a pregnant mare to provide a source of material; she was also a source of amusement to the graduate students in the department who christened her Maria. However, the development of efficient routes for the synthesis is estrone made its production from natural sources obsolete. Wheeler also collaborated with several chemists in industry; one paper was on the determination of carotene in dried peas. The results were analysed statistically and methods were developed to determine carotene accurately to three parts per million. He also published a study of the compositions of Irish and American tobaccos.

Physical Chemistry and Physics

The papers on the thermal decomposition of methane (*see* page 24) were part of a group of theoretical papers that Wheeler published between 1927 and 1937. The work was started while he was still at Woolwich, continued in Winnington and in India, but until he went to India it was essentially a spare-time occupation. The first paper of the series derived an empirical formula for expressing the mutual solubility of two salts with a common ion. This was followed in 1931 by two papers in the *Philosophical Magazine* on boiling point rules. The conclusion from this work is that boiling point rules are special cases of the following principle : if in a system 1 the relation between the value x_1 of a property and the value y_1 of a second property, or variable states of the system, is expressed by $\phi(x_1)=f_1(y_1)$ and if x_1 and x_2, 2 values of one property, are related by the condition that $x_1 = F(x_2)$, and F and ϕ are of such a form that $\phi(x_1) = \phi\,[F(x_2)] = k_1 + k_2\,\phi\,(x_2)$ then it follows that $f_1(y_1)$ and $f_1(y_2)$ are linearly related. This work led Wheeler to publish in 1931, a paper on the general theory of solutions of strong electrolytes. Wheeler was very proud of this paper, particularly as it was published in the *Physikalische Zeitschrift,* a journal of which Debye was the editor. In this paper, Wheeler showed that for a dilute solution of a salt yielding small ions, the electrical work done by the interionic forces can be expressed as a product of a potential energy corresponding to the law of force specified multiplied by a sum of series, each term of which consists of a power of the ratio of the potential energy to a thermal kinetic energy. He showed that the concept could simplify the presentation of the Debye-Hückel theory.

Later, the concepts and calculations were generalized and applied to solutions of strong electrolytes with small ions and with ions of finite size, to the potential of crystal lattices, and to gaseous equations of state, including the van der Waals equation. Using thermodynamic and dimensional considerations, he was able to calculate values of the second virial constant of a gas consisting of small physically symmetrical particles and found values which are comparable to those calculated by Lennard-Jones. The electrostatic potentials of several types of crystal lattices were also calculated. Again he got values which agreed with those derived by others using more complicated calculations. He also considered the linear relationships between the radii of molecules.

In 1934, Wheeler published the first of a series of papers on the theory of liquids His work started from two equations deduced by another worker but certain assumptions used by that worker were not satisfactory. Wheeler's ideas were based on the assumption that at temperatures of low vapour pressure, the force constant of attraction between molecules does not vary with temperature but that the apparent diameter of the molecules in a liquid increases with temperature and so the molecules on the average continue to touch. He pictured a liquid as a close-packed swarm of bees. The swarm stays together; each bee is crawling on his neighbours being in turn crawled on. A small number in relation to the total in the swarm are leaving it while others join. At times the swarm will be slightly compressed and at other times lightly expanded, but on the whole it has a definite size. Each bee is also imagined to rotate. Formulae were worked out to calculate

a variety of thermodynamic properties, including the latent heat of vaporisation, differences of specific heats of the liquid, its vapour, and surface tensions. The agreement between calculated and experimental values was good. The original formulae were extended, by taking account of the vibration of molecules, to derive formulae for properties such as viscosity, the coefficient of thermal expansion and compressibility. The calculation of properties deduced in the first three parts required that one property (e.g., density) be known before the rest could be calculated. In the fourth part, equations were deduced for the forces on a particle vibrating in a spherical space under the influence of attractive and repulsive forces between that particle and uniformly distributed matter outside the spherical space. It was then shown that using those equations the properties of a liquid could be calculated if the temperature, and the fundamental properties of a molecule, the forces which it generates, are known. The theory was then applied to the rates of reactions in liquids and it was shown that it could afford a satisfactory picture of the mechanism of simple unimolecular and bimolecular reactions. Diffusion and vapour pressure phenomena were next discussed. Wheeler's work on liquids was an impressive feat that does not seem to have received the recognition it deserved.*

One other theoretical study comes from Wheeler's Indian days. This paper, which was done in collaboration with the Professor of Mathematics at the Institute, was received by the journal three to four months after his arrival in India; apparently, he lost no time in getting down to research. The paper examines the geometry by which chains are converted into rings. While it appeared to disprove some ideas previously put forward by Ingold, it was based on the false idea that rings are planar.

Wheeler published two papers on theoretical chemistry after he left India. They resulted from the course on quantum mechanics he took from Schrödinger. He calculated the energies of the 1s2s triplet state of the helium atom and related two electron atoms by a variational method and obtained values of the energy which agreed with such experimental results as were available and also with previous calculations that had used more parameters, and functions that could only be minimised by graphical methods. He also developed a simple function relating the energy of a state under consideration to the atomic number. A second paper described a simplification of the evaluation of Schrödinger intensity integrals. Those two papers illustrate the ability Wheeler showed throughout his theoretical work, to find a way of simplifying calculations while still getting good agreement with experiments.

Physical Organic Chemistry

In view of Wheeler's interests in physical chemistry, it is not surprising that his first work in organic chemistry was mechanistic. As he went out by boat, to India in 1931, he laid plans for a study of benzoin condensation which eventually resulted in six papers; in four of these he was the principal author; his name did

*See E. A. Moelwyn-Hughes '*The Kinetics of Reaction in Solution*' Clarendon Press, Oxford 1947, pp. 249 and 283; and idem. '*Physical Chemistry*', Pergamon, Oxford 1961, pp. 974.

not appear on the other two which were written by his co-worker D. R. Nadkarni. The study was undertaken because there were contradictions in the literature about whether water was necessary for the condensation to take place. The discrepancy was of some importance because Lapworth's mechanism involved the formation of cyanide ion. Wheeler's careful study established that mixing pure benzaldehyde with pure potassium cyanide leads to two concurrent reactions: a fast homogeneous autocatalytic reaction that required the presence of a trace of benzoin; and a slow heterogeneous reaction between benzaldehyde and cyanide. The homogeneous reaction involves a trace of cyanide dissolved in benzaldehyde. In the heterogeneous reaction, benzaldehyde is absorbed on potassium cyanide with formation of the cyanohydrin. It was observed that the heterogeneous reaction was inhibited and the inhibition was eventually traced to traces of sulphur coming from the rubber rings used to seal the reaction vessels. Nadkarni then followed up on this work showing that compounds such as potassium chloride, sodium chloride, potassium iodide, and quinol all inhibit the heterogeneous reaction. The effect of the iodide and quinol was due to absorption of the service of the cyanide. The inhibitory actions of the chlorides appear to be different and involved a direct reaction between solid chloride and cyanide. Water promoted the homogeneous reaction by dissolving cyanide but the effect levels off. Water also reverses the effect of the inhibitors on the heterogeneous reaction.

Solvents such as benzene, cyclohexane, and chloroform did not affect the heterogeneous reaction but slowed the homogeneous one because they precipitated cyanide from benzaldehyde. The effect of solvents containing hydroxyl groups is more complicated. In all cases they accelerate the reaction probably by increasing the quantity of potassium cyanide dissolved. But they tend, in certain quantities, to delay the start of the homogeneous reaction. Sulphur and its derivatives inhibit the heterogeneous reaction by being absorbed on the cyanide. Some elegant work was done to estimate the amount of cyanide functioning in the presence of the inhibitor. Various inhibitors differed greatly in their effects; quinol, for example, worked in dilutions 5,000 times greater than carbon disulphide. The original studies were all done at 100°. The last paper in the series described work at temperatures between 60° and 120°. Below 80° the rate constants of both the heterogeneous and homogeneous reactions decreased without much regularity. Between 80° and 110° the rate constant for the homogeneous reaction did not change; that of the heterogeneous reaction doubled for each 10 degrees increased in temperature. These effects break down above 110° because benzoin itself starts to decompose.

Further work on the kinetics of heterogeneous reactions followed. This, of course, is a very difficult field. Two papers described a careful study of the reaction between benzyl chloride and silver nitrate. The velocity of the reaction with no diluents is independent of the amount of benzyl chloride and the speed of shaking but is proportional to the surface of silver nitrate present. Water inhibits the reaction as do such organic solvents as ether, chloroform and carbon tetrachloride. The experimental results can be reproduced by a kinetic equation derived on the assumption that rate of reaction depends only on the surface of silver nitrate present.

Synthetic Organic Chemistry

Wheeler started synthetic work shortly after he arrived in India. In addition to his major subject of flavonoid chemistry (discussed below), he investigated two other areas, one involving nitrogen compounds and the other the reactions of various benzyl halides.

The work on nitrogen compounds covered the reactions of certain chloral products, the chemistry of amidines, and the reactions of di-imidochlorides. It is possible that the chloral work was a completion of work that some students had started with Meldrum. The other nitrogen work may have arisen from interests he acquired while working at Woolwich. For example, the object of making amidines seems to have been to examine their tautomerism. However, this work was abandoned after he left India.

In 1937 and 1938, Wheeler published four papers on the reactivity of benzyl halides. It was found that formic acid reacts with benzyl, benzal and benzotrichlorides and that the reactions could be used as a way of estimating side chain halogens. The kinetics of the reaction of formic acid with benzyl chloride were examined. The rates of the reaction were shown to be less than those calculated from the heat of activation. Application of Wheeler's ideas on theory of liquids to the results suggested that formic acid reacted in an activated form that was only present in traces; presumably, the activated form was protonated formic acid. Bromination of benzyl chloride and benzyl bromide and chlorination of benzyl bromide were then studied and mixed laterally-halogentated toluenes were obtained. The final work in the series was a study of the reactions of the ω-halogen atom of *p*-alkoxybenzyl halides.

His interest in natural products led to research on the preparation of acetophenone derivatives required for the synthesis of substances containing coumaran and γ-pyrone nuclei. Later, in the Dublin Laboratory, a demand for phloracetophenone trimethyl ether led to his discovery that the use of sulphuric acid as catalyst in acylating the trimethyl ether gave the required acetophenone in quantitative yields. In the course of the work, anomalous results in the chemistry of alkoxynaphthyl ketones were cleared up.

In the middle 1930s, he began his interest in flavonoids and this, of course, was to be the field on which he concentrated later in Dublin and in which he made his most important contributions. This work covered several broad areas.

Chalcone Dihalides

Wheeler and his collaborators made several important discoveries in the reactions α,β-dihalogeno-ketones; one leading to an excellent synthesis of aurones and others to useful syntheses of flavones. Difficulties in purifying a complex mixture of products prevented their discovery of the synthesis of dihydroflavonols now known as the 'Rasoda reaction.'

The Wheeler aurone synthesis by the cyclization of β-alkoxy-α-bromo-2′-hydroxydihydrochalcones derives from the discovery by Nadkarni, Warriar, and Wheeler that 2′-hydroxychalcone dibromides containing a 4-alkoxyl substituent,

when cyclized by base in hot alcohol, are initially converted into β-alkoxy-α-bromo-ketones before cyclizing to form aurones. Only 2- or 4- alkoxyl substituted chalcone dihalides form β-alkoxy-α-halogenoketones but this limitation does not detract in practice from the Wheeler aurone synthesis as naturally occurring aurones are in general 4′-substituted.

In 1939, he introduced a flavone synthesis based on the reaction of 2-methoxychalcone dibromides with sodium methoxide. This reaction yields β, 2-dimethoxychalcones which, on demethylation, form flavones *via* 1 (2-hydroxyphenyl)-3-aryl-1, 3-diketones.

Another Wheeler flavone synthesis is a pyrolysis reaction carried out on 2′-hydroxychalcone dihalides. It was introduced by Wheeler and his co-workers as a simple authentic synthesis of flavones at a time when the Emilewicz-von Kostanecki cyclization of chalcone dibromides by aqueous alcoholic alkali was thought to be unreliable—aurones rather than flavones were often inexplicably obtained.

Wheeler made several contributions to the establishment of the Emilewicz-von Kostanecki reaction as a reliable synthesis of naturally occurring flavones, showing, in particular, that flavones and not aurones are the major products obtain by cyclizing phloracetophenone-derived chalcone dibromides with the typical reagent, aqueous alcoholic alkali. Hutchins and Wheeler observed that, with alcoholic potassium cyanide, these chalcone dibromides yield *only* flavones. This observation lay dormant until other workers showed that aurone formation by phloracetophenone-derived chalcone dibromides in the Emilewicz-von Kostanecki reaction parallels hydroxide concentration, with no aurone but an excellent yield of flavone being formed in dilute aqueous alcoholic alkali.

Wheeler's earliest work on chalcone dihalides also involved their reactions with alcoholic potassium cyanide and showed that the propionitriles so produced are formed *via* the parent chalcones. Surprisingly, this synthesis of propionitriles is sometimes more satisfactory than the simple addition of hydrogen cyanide to chalcones.

Having shown that aurone dibromides are generally similar to chalcone dibromides in their reactions, Wheeler and his collaborators discovered that 4′-alkoxyaurone dibromides undergo ring-expansion with alcoholic potassium cyanide to form flavones.

Baker-Venkataraman Transformation

The Baker-Venkataraman transformation, discovered independently by Baker and Venkataraman, in 1933, was studied by Wheeler and his co-workers in India who found that sodium in ether or boiling toluene or sodium ethoxide in alcohol also brought about the rearrangement and in view of these results suggested that the reaction might be regarded as an internal Claisen condensation. This problem was further studied by Wheeler and his colleagues in Ireland. They found that a variety of weak acids, sodium hydroxide, phenoxide, peroxide, hydride etc., were effective reagents for the transformation of *o*-aroyloxyacetoarones into the corresponding *o*-hydroxydiaroylmethanes. They concluded that the reaction involves

a base-catalysed intramolecular condensation of the Claisen type. The effect of nitro and methoxyl groups on the transformation was discussed. That the transformation is intra- and not inter-molecular was demonstrated when a mixture of two aroyloxyacetoarones in the same solution underwent the Baker-Venkataraman transformation and failed to give "crossed products."

A suggestion by Auwers in 1910 that his synthesis of 2-acyl-coumaran-3-ones by the action of potassium carbonate in boiling benzene on *o*-acyloxy-ω-chloracetophenones involved transformation to the corresponding chloro diketone which immediately cyclised was confirmed by Wheeler when he showed that the reaction almost certainly involved an internal Claisen condensation of the Baker-Venkataraman type, and supported the view held by other workers that the Auwers synthesis was the first known example of a Baker-Venkataraman transformation.

With Nowlan and Slavin Wheeler studied the effect of bond structure on the transformation. The work concerned in transformations across the $C_{(1)}$-$C_{(2)}$ and $C_{(2)}$-$C_{(3)}$ bonds of naphthalene, which have, as regards the chemical reactivity of naphthalene compounds, the quality, respectively, of double and single bonds. The results indicated that generally transformations take place across the $C_{(2)}$-$C_{(3)}$ single type bond in naphthalene more rapidly than across the $C_{(1)}$-$C_{(2)}$ double type bond and support the view put forward previously as to the mechanism of the transformation. A study of the effect of bond structure on the Baker-Venkataraman transformation of acetylanisoyloxyindanes and benzoyloxytetrahydro-acetonaphthone indicated that the 1,2-bond in 5,6,7,8-tetrahydronaphthalene derivatives has a higher order than the 2,3-bond.

New synthesis of flavones, diflavones, flavonols, and chromonols by cyclisation of *o*-aroyloxyacetoarones in glycerol, at about 250° were shown to proceed by a thermally produced Baker-Venkataraman transformation.

5,8-and 2'-Flavonoid Rearrangements

Rearrangement of a 5,7,8- to a 5,6,7- trihydroxyflavone during hydriodic acid demethylation had been observed by Wessely and Möser in 1930. In the following years, there was much disagreement among various workers as to the action of the acid on *o*-alkylated 5,7,8,-trihydroxyflavones. In 1939, Wheeler and his co-workers published an account of their investigations into the constitution of Oroxylin-A a flavone which they had previously isolated from a natural source. In an attempted synthesis of the flavone by a known route, they obtained not the expected 5,7-dihydroxy-6-methoxyflavone but 7-hydroxy-5, 8-dimethoxyflavone which on demethylation by hydriodic acid underwent rearrangement and yielded 5,6,7-trihydroxyflavone(baicalein). On demethylation with aluminium chloride the 5,7,8-trimethoxyflavone underwent normal demethylation and gave 5,7,8-trihydroxyflavone obtained pure for the first time and 5,7-dihydroxy-8-methoxyflavone (wogonin). This was the first synthesis of this naturally occurring flavone.

As a consequence of this work, it was suggested that rearrangement of 5,7,8-alkoxyflavones on demethylation by hydriodic acid is accompanied by ring

opening of the pyrone ring followed by ring closure with formation of the 5,6,7- or 5,7,8-trihydroxyflavone. This suggestion accounted for differences obtained by previous workers. Consequently, it was recommended that when using hydriodic acid where rearrangement could occur remethylation should be carried out for further comparion. The use of aluminium chloride as a safer demethylating agent was also pointed out. Both suggestions have stood the test of time.

Wheeler continued to be interested in flavonoid rearrangements and made important contributions in this area until his death. With colleagues in Dublin he published work on the rearrangements of 5,8-dialkoxyflavonols 5,8-dihydroxychromonols, 1,4-dihydroxyxanthones, a coumarin and 5,8-dihydroxyflavylium salt and on the relative stability of 5,8- and 5,6-dihydroxyflavones.

Related to the 5,8-rearrangement is that of flavones substituted in the 2′-position. In 1952, Wheeler with his colleague Philbin found that on demethylation of 2′,5′-dimethoxyflavone with hydriodic acid in phenol at 170° under pressure rearrangement occurred to 6,2′-dihydroxyflavone presumably with intermediate formation of the diketone of the disalicyloylmethane type. It was considered that this observation might be significant in connection with the synthesis of naturally occurring 2′-hydroxyflavones which require demethylation of the corresponding 2′-methoxyflavones. Further study of the 2′-rearrangement showed that under sufficiently drastic conditions of demethylation by hydriodic acid certain 2′-methoxyflavones rearranged to give related 2′-hydroxyflavones in which 2-phenyl group and the fused aromatic ring of the original flavone are interchanged. An interesting extension of this work involved a combined 5,8 and a 2′-rearrangement when it was found that demethylation of 5,8,2′-trimethoxyflavone or its isomer 2,′3′,6′-trimethoxyflavone with hydriodic acid yielded in each case 5,6,2′-trihydroxyflavone. The decyclisation mechanism previously suggested for the 5,8- and 2′-rearrangements was confirmed.

Lotoflavin, a naturally occurring flavone isolated in 1901 was assigned the structure 5,7,2′,4-tetrahydroxyflavone. Two syntheses of this compound involving hydriodic acid had been reported but its properties did not agree with those reported for Lotoflavin. In both syntheses the final step involved demethylation with hydriodic acid. On the grounds that rearrangement could have occurred during demethylation Wheeler's group synthesised 5,7,2′,4-tetramethoxy- and 7,2′, 4, 6′-tetramethoxy-flavones. Demethylation of the two flavones with hydriodic acid in phenol gave the normal product from 5,7,2′,4′-tetramethoxy- but in the case of 7,2′,4′,6′-tetramethoxyflavone complete rearrangement occurred and the product was 5,7,2′,4′-tetrahydroxyflavone. Examination of two specimens of the original lotoflavin showed it to be a mixture of quercetin and kaempferol and after a lapse of over fifty years the lotoflavin problem was solved.

Algar-Flynn-Oymada Reaction (AFO)

Conflicting reports in the literature with regard to the action of alkaline hydrogen peroxide on certain 2′-hydroxy-6′-methoxychalcones led wheeler and co-workers to re-investigate this aspect of the Algar-Flynn-Oyamada (AFO) reaction.

Under the conditions of this oxidation reaction, there were several reports of the formation of aurones instead of the expected flavonols when a methoxyl group was present in the 6′-position of the chalcone. However, there was also reports of flavonols being obtained from such chalcones. These results were reconciled when 2′-hydroxy-4,4′,5′,6′-tetramethoxychalcone and 2′-hydroxy-2,6′-dimethoxychalcone were found to give the corresponding aurones when the reaction was carried out in cold, but gave mainly the flavonols when the reaction was carried out in heat.

The reaction was extended when it was found that oxidation of 2′-hydroxy-3′, 4′-dimethoxychalcones gave, in addition to the usual products, 2-benzyl-2-hydroxycoumaran-3-ones ("hydrated" aurones) and 2-arylbenzofuran-3-carboxylic acids, each new as regards this reaction. The production of 2-arylbenzofuran-3-carboxylic acids as major products was subsequently found to apply to simple 2′-hydroxychalcones under certain reaction conditions. Decarboxylation of the acids provided a new syrthetic route to 2-arylbenzofurans.

Wheeler suggested that the production of benzofuran-3-carboxylic acids in the AFO reaction results from benzylic acid transformations of intermediate α-diketones. The rearrangement involved could proceed through either a benzyl or anaryl group migration. A carbon-14 tracer study showed that the reaction occurs predominantly through a benzyl group migration.

A paper published in 1963 discussed discrepancies in the published work on the AFO reaction. Many of the reactions were re-examined and new chalcones, flavonols, aurones, 2-arylmethyl-2-hydroxycoumaran-3-ones and 2-arylbenzofuran-3-carboxylic acids were described. The mechanisms for the production of these compounds the effect of substituents in the starting chalcones, and the effect of reaction conditions on the course of these reactions were discussed and clarified.

An extensive review of the occurrence, synthesis and reactions of dihydroflavonols (one of the products of the AFO reaction) was published in 1957.

In the course of the work related to the AFO reaction five new syntheses of flavonols were discovered.

In re-investigating early work on the products of condensation of ω-halogeno-2′-hydroxyacetophenones with aromatic aldehydes in the presence of alkali, Wheeler found that while with dilute alkali the condensation yields aurones, flavonols were the main products of the reaction when concentrated alkali was used. In an extension of this work several flavonols were prepared. With increase in temperature or a deficiency in alkali aurones, hitherto the only known products, were obtained.

Alkaline hydrogen peroxide oxidation of aurones produced the corresponding flavonols and in some cases aurone epoxides were obtained. When the aurones in pyridine solution were treated with sodium peroxide the related aroylcoumaranones resulted.

Another new flavonol synthesis was described in 1959 when it was found that *o*-hydroxydibenzoymethanes, in chloroform solution on treatment with perfomic acid gave flavonols.

2′-Tosyloxychalcone epoxide, prepared by means of alkaline hydrogen peroxide oxidation of 2′-tosyloxychalcone, on treatment with alkali at 65° was quantitatively converted into flavonol. Treatment of the epoxide with boron trifluoride etherate

under nitrogen gave dihydroflavonol and flavonol. This was also a new method for the preparation of dihydroflavonols.

In a review on studies in the chemistry of flavonoid epoxides preliminary work on the oxidation of flavindogenides was reported. Isomeric pairs of flavindogenides epoxides were obtained which on treatment with dilute sulphuric acid gave dihydroflavonols and flavonols.

Stereochemistry

Interest in conformation analysis was widespread in the 1950's and in 1958 Wheeler with Philbin published a note on the conformation of chromanones and related compounds. Using infrared data, calculations and a study of specially constructed models they suggested that the heterocylic nucleus of a chromanone or a dihydropyran molecule will, except for atom-2 be co-planar with the benzene nucleus and proposed that these compounds may exist in a "sofa" rather than in the previously accepted "half-chair" conformation. The note contains a discussion on the conformation of the various exocylic bonds in the molecules.

In 1959, the Dublin group in collaboration with Professor Bognar of Debrecen, Hungary (Visiting Professor in Dublin in 1958) published a new method for the preparation of 4-hydroxyflavans. The method contained features of stereochemical interest and involved the reduction of 4-oximoflavan to the amine which was then converted into the 4-hydroxyflavan. The production of these oximes opened a route to the flavan-3,4-diols (leucoanthocyanidins).

Later work by the Wheeler school with Bongar and with Dr Lillya of Harvard University enabled configurations and conformations to be assigned to the flavan-4-ols. Application of nuclear magnetic resonance to the benzoates of flavan-4α- and 4β-ol showed that in flavan-4α-ol produced by catalytic hydrogenation, the 2-phenyl and 4-hydroxyl groups are both equatorial. The flavan-4α-ol obtained *via* the oxime has the 2-phenyl group equatorial and the 4-hydroxyl group axial.

Further research on the stereochemistry of flavan-3,4-diols in collaboration with Professor Corey at Harvard allowed unambiguous assignment of configuration to the benzoates and carbonates of two flavan-3,4-diols and thus to the parent diols. These results were confirmed by infrared studies of intramolecular hydrogen bonding in the flavan-3,4-diols.

The synthesis of flav-2- and flav-3-ene made possible further study of flavan-3, 4-diols. The structures of the flavenes were established by NMR studies. Treatment of flav-3-ene with osmium tetroxide gave 2,3-*trans* flavan-3,4-*cis* diol thus providing a new approach to the stereospecific synthesis of leucoanthocyanidins. The synthesis of flav-3-ene provided the starting material for the preparation of racemates of 4-acetoxy-3-bromoflavans; the preparation and identification of the four possible racemates was reported after Wheeler's death.

Apart from his contributions in specific areas already discussed, Wheeler devised many new synthesis in the flavonoid field and made significant advances in other areas.

Historical Studies

In 1943, Wheeler was approached to give a lecture in April 1944 at the Royal Dublin Society on the life of Sir Robert Kane (1809–90), a well-known Irish chemist. As the lecture was to commemorate the publication in 1844 of Kane's important book *"The Industrial Resources of Ireland"*, Wheeler suggested that the Society should organize a symposium on the natural resources of Ireland. They agreed and so Wheeler's lecture was followed by talks given by specialists in mechanical engineering, civil engineering, geology, agriculture, and forestry. These lectures were published by the Royal Dublin Society. Wheeler then published two accounts of Kane's life one in *Endeavour,* and the other in *Studies* (an Irish intellectual journal). Wheeler enjoyed this work not only from the point of view of chemistry but also from learning about Kane's many other activities and from tracing Kane's family. He then wrote a life of the chemist Sullivan who succeeded Kane as President of Queen's College, Cork, and this was followed by work on the life of William Higgins. The interest in Higgins continued for the rest of Wheeler's life. Later Wheeler collaborated with the well-known chemical historian J. R. Partington to write a book describing Higgins's life and work. Higgins is interesting because he pre-dated Dalton in developing the ideas of atoms, their combinations into molecules and the concept of structural formulae; however, he did not develop the concept of atomic weights.

Wheeler then became interested in the history of the various chairs of chemistry in Ireland, particularly that at the University College which descended on one side from Higgins's chair at the Royal Dublin Society, and on the other from that in the ill-fated Catholic University of Ireland. That University was established about 1850 and the first rector, John Henry Newman, later Cardinal Newman, delivered a series of lectures on the idea of a university. The lectures became very famous and to commemorate their centenary, University College Dublin organized a series of lectures on Newman. Wheeler gave the one on Newman and Science. He enjoyed these historical studies greatly and planned to do more of them when he retired.

Education

When Wheeler became Professor at University College in 1945, he was immediately struck by how much more complicated chemistry had become in the 25 years since he got his primary degree. He was also shocked by how little University courses, especially the first year courses, had changed since he had been a student. So as he reformed the curriculum at University College, he started to write about and lecture on the training of a chemist.

He felt a chemist should be someone who understood chemistry in general and is trained to think for himself and be a lifelong student; he need not do routine operations as well as those he supervised, or as Wheeler put it more colourfully *'The foreman need not be able to knock out every member of his gang.'* He felt too much training was directed towards producing analysis and that one could be a good chemist even if one was not a six base six acid man with a good eye for the

colour of a hydrogen sulphide precipitate. Similarly, first year courses ought to move from showing how Dalton deduced the atomic theory on the basis of the laws of chemical combination and start instead with the electronic structure of the atom and show how the laws follow from atomic theory. At UCD he used to say that first year courses, both lectures and laboratories, contained little if anything that would have been unfamiliar to Kane or Kekule; this, however, he changed rapidly.

Wheeler said that organic chemists were too conservative about introducing new ideas into their discipline, such as electronic theory. At the same time, he thought that honours courses in England were too specialized, concentrated too much on producing graduates for research rather than for industry, and that the large number of PhD.s being produced was devaluing research because too much organic chemistry research was little more than development predictable by analogy. At the conference in 1956 sponsored by the Royal Institute of Chemistry on the Education and Training of the Chemist, Wheeler's idea was that a chemist need not be a good routine analyst. This was described as 'nonsense and a shocking thought.' Indeed, most of his ideas were considered rather novel and daring about 25 years ago but as the years have gone on, most of the changes he suggested have been introduced.

When Wheeler returned to University life, he found himself faced with the job of teaching a course on inorganic chemistry and he continued to do this for some 7-8 years. This was an area of chemistry in which he had done little work and so he gave the course in the most logical way possible, that is by stressing the relationship between electronic structures of atoms and their chemistry. Again in 1945, this was a novel idea as inorganic chemistry was only just starting the renaissance that has taken place over the last 30 years. A result of this approach was the publicaion in *Chemistry and Industry* of a new form of the Periodic Table which stressed similarities of electronic configurations between elements in the same chemical family.

Another way in which he showed his propensity for systematizing knowledge came from his impatience with the custom of associating particular reactions with the names of their discoverer. With Dr J. E. Gowan he produced an invaluable *'Name Index of Organic Reactions'**. The Index of Organic Reactions was very successful and after its original publication as a small booklet by the Society of Chemical Industry in 1950, it was re-issued 10 years later as a book published by Longman's. Although many new reactions have come into use since 1960, the Index is still very useful.

Wheeler's passion for modernizing the training of chemists in universities led him to an interest in the training in secondary schools. He first became aware of the problems when he had to set matriculation examinations for the National University of Ireland. He realised to his surprise that the examinations were literally nineteenth century in their character. The sorts of criticisms he expressed

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*Amusingly enough Wheeler himself associated some names with reactions, e.g., the Baker-Venkataraman transformation. When the Index came out, Baker wrote to Wheeler congratulating him on the Index and saying that while he agreed it was undesirable to use names to describe reactions, he could now hardly complain as he himself had been so honoured.

were also expressed in 1958 at an OEEC meeting in Germany on the teaching of chemistry in secondary schools. Early in 1960, Wheeler gave the Keynote address at a similar OEEC conference in Ireland; he covered a wide range of subjects related to training in chemistry of pupils between the ages of 14 and 18. He was then asked to serve as President of the Irish Science Teachers Association and gave the Presidential Address in April 1962 on Billiard Balls and Hard Water. In this, he showed by a study of examination papers and text books that a person who studied a text written in 1830 could have done creditably or a school leaving examination in 1960. He found examination papers dating back to 1844 and again and again he found the same questions coming up year after year. The title of the lecture was based on the point that all theory in schools was derived from thinking of atoms as billiard balls while examination questions on hard water had appeared first in 1844 and had continued to do so ever since. The point that he made was that the curricula at secondary schools were in need of drastic changes. As a result of his pressure the curricula were completely modernised. The fact that the lecture he was to give in Cork the day he died was Billiard Balls and Hard Water shows that the reform of school curricula was a continuing interest until his death.

Miscellaneous Subjects

Wheeler's first paper in 1921 was a remarkable one for a young man starting his career. It was a criticism of the system of organic nomenclature. He suggested that as the present system was not satisfactory, an international congress ought to be called to scrap the current system and start from scratch in devising a rational nomenclature. He made some suggestions for such a system in which various functionalities were denoted by various letters, e.g., *b* indicated a double bond, and *o* an alcohol. These ideas were developed and applied to the naming of a variety of compounds. In 1923, he proposed a new linear representation of structures of all orgaric compounds. The idea was that all structures, open chain and ring, could be reduced to a single line representation. Several examples were given including a dibenzocyclobutadiene, a type of compound that was not prepared until many years afterwards. This work attracted the attention of Dr A. M. Patterson who was then editor of *Chemical Abstracts*. These papers showed Wheeler's impatience with sloppiness and his ability to bring forward ideas that were far in advance of their time.

His other writings covered many subjects. For example, there were brief reports on a number of projects that seemed to have been abandoned. One article is a mild criticism of the refusal of the Ingold and Robinson schools of electronic theory to recognise each others' work. Some articles were written essentially for the intelligent layman, e.g., two articles on atomic energy. Then there were several commentaries on the problems of scientists and sciences. He was acutely aware of the problems brought about by the increased flood of the chemical literature. Many of his book reviews are still interesting and amusing to read. He wrote about various meetings that he had organised in Dublin. While he was not a particularly nationalistic person in his views and did not hesitate to criticise

his own country, he objected to unfair attacks and so in 1959 wrote a polemical letter to *Science* demolishing an author who had been imprudent enough to write slightingly of Ireland. He also wrote an article for *The Times* (*London*) review of industry on education and research in Ireland which was published after his death. In 1958, he wrote on research in industry in Ireland in the *Irish Times Review* and pointed out the slow progress in this area. He stated as he had often done before that it was rather sad that a native government had fused the Royal College of Science of Ireland with UCD and thus removed the only place where there was some attention devoted to applied work and he pointed out the irony that such an institution had been established by an alien government.

The list of publications in this article was prepared by Wheeler himself about 1960, but does not include some minor contributions. In addition to his scientific work, Wheeler, while in the State Laboratory, published a few articles in an Irish humorous magazine; in there he poked gentle fun at some of the methods used by civil servants.

In summary, his record shows a most substantial contribution to the area of flavonoid chemistry and in addition a breadth of interest with excellent contributions in a wide variety of areas more widespread than one usually finds in chemists. Indeed there can be few if any chemists in this century whose publications cover such broad areas of chemistry.

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BARADANANDA CHATTERJEE

(1912–1967)

Elected F.N.I. 1960

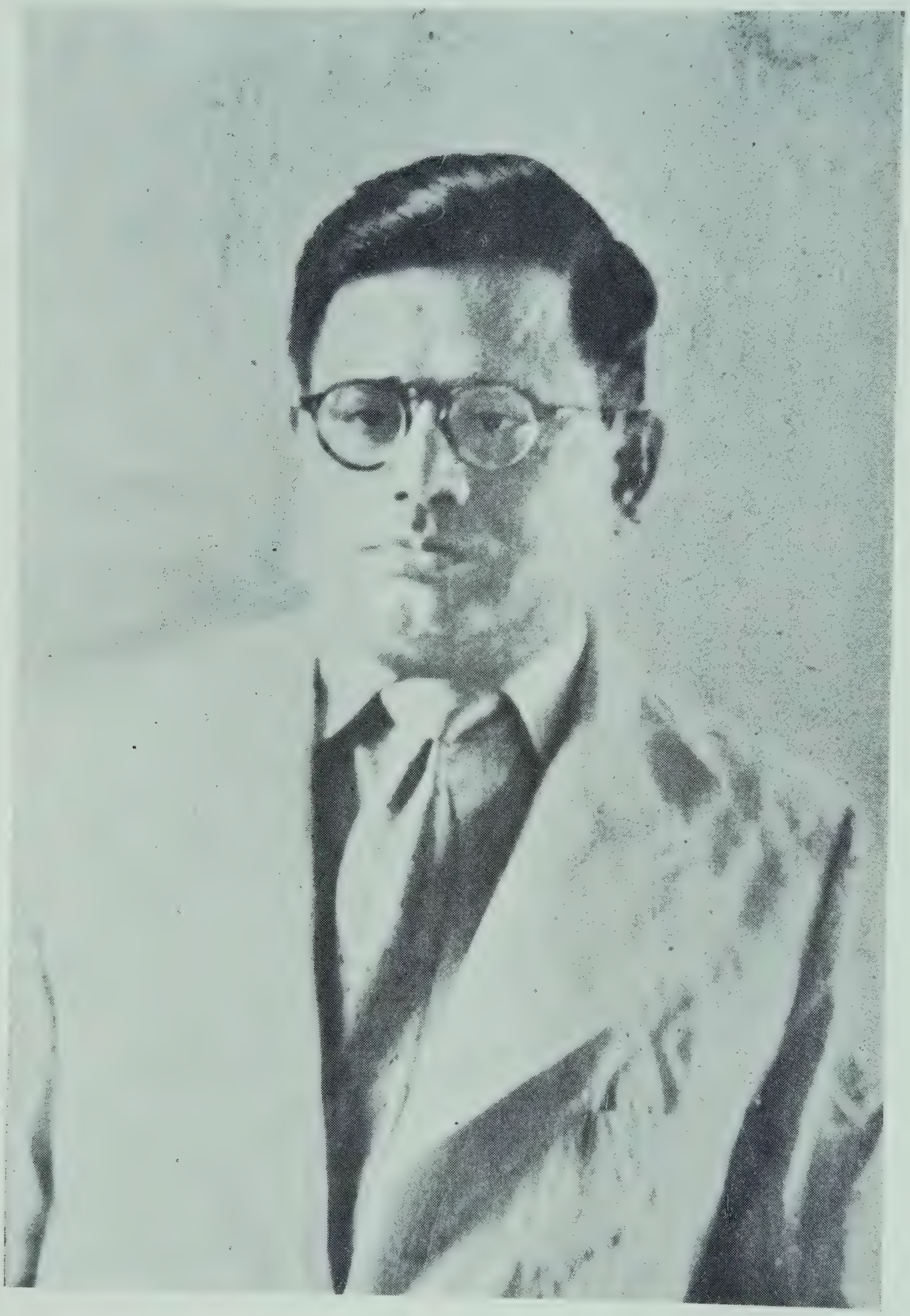
Early Life and Education

Baradananda Chatterjee was born in 1912 in Guskara, a village in the district of Burdwan, West Bengal. Having lost his parents before he was nine years old, he grew up under the care of his elder brother who doted upon his gentle, handsome and bright-eyed younger brother with all the affection of a father. His early education was not particularly eventful but he was remembered as a diligent and disciplined student in his school and college careers. In later life he made virtues of these qualities.

Dr Chatterjee passed his B.Sc. examination in 1932 with Second Class Honours in Chemistry from the City College, Calcutta, and in 1934 he obtained his M.Sc. degree of the University of Calcutta with a first Class with Physical Chemistry as his special subject. Soon after, he began his research work under Professor J. N. Mukherjee, then Khaira Professor of Chemistry, University of Calcutta. He was admitted to the degree of Doctor of Science on the merit of his thesis on "Electrochemical properties of silicic acid sols; the role of aluminium in interaction of hydrogen clays with neutral salts, and the use of sodium perrocyanide as a dispersing agent in the mechanical analysis of soils". During this period he was appointed research assistant under a research scheme sponsored by the Indian (then Imperial) Council of Agricultural Research. In 1937, he was awarded by the University of Calcutta the coveted *Nagarjuna Gold Medal* for his work on the "Electrochemical properties of colloidal silicic acid" which was adjudged the year's best piece of research work. Two other papers on the electrochemical properties of silicic acid sols published by him in the *Journal of the Indian Chemical Society,* won him the Society's *J. M. Das Gupta Memorial Gold Medal.* During 1942–46, he worked as an honorary lecturer in the University of Calcutta in the Department of Chemistry. In 1946, he was awarded a Government of India overseas research scholarship which enabled him to spend two years at the Universities of Wisconsin, Missouri and Cornell in USA and carry out post-doctoral research work in the laboratories of such eminent soil scientists as Professors C. E. Marshall, E. Troug and R. Pradfield.

Professional Career

On his return to India, Dr Chatterjee was appointed as Physical Chemist at the Indian Agricultural Research Institute, New Delhi. Here, he reorganised the



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Soil Science and Analytical Sections of the Division of Chemistry and gave courses in Physics and Chemistry of Soils and Clays to the post-graduate students.

Dr Chatterjee joined the Bengal Engineering College, Sibpur, Howrah, West Bengal in 1947 and became Professor and Head of the Department of Chemistry, Metallurgy and Geology in 1956 and later its Vice-Principal in 1964.

He was associated with a rumber of learned societies and institutions in various capacities. They include : Indian Chemical Society, Indian Science News Association, Indian Science Congress Association, Indian Association for the Cultivation of Science, Indian Society of Soil Science, Indian Institute of Metals, National Institute of Sciences of India (now Indian National Science Academy), International Society of Soil Science and Society of Sigma Xi (USA), Calcutta University as member of the Senate, Faculties of Agriculture and Engineering, and Undergraduate Boards of Studies in Engineering and Geology. He was for sometime Associate Editor, *Indian Journal of Chemistry,* Member of the Standing Committee on Manures and Fertilizers, Government of West Bengal, Teacher Representative on the Governing Body of the Bengal Engineering College.

Scientific Contributions

As mentioned earlier, Dr Chatterjee began his research work in the laboratory of Professor J. N. Mukherjee who was at that time interested in the properties of soil colloids. The latter are silicates in which silica or silicic acid is the major constituent. In order, therefore, to understand the colloidal and surface characteristics of silicates, Dr Chatterjee chose to study the colloidal properties of silicic acid sols in great detail. Preliminary work showed that silicic acid sol was unstable and readily formed a gel in presence of trace and accidental impurities, so that reproducible experiments were difficult to perform with it. Here, Dr Chatterjee's manipulative skill, ingenuity and close attention to detail resolved the difficulty. With the help of careful electrometric titrations he could establish their characteristic features, the regular cation effects, confirming the lyotrope series, and also the specific cation effects which violated the series, and the increase in titratable acidity in presence of neutral salts. The interaction of bases and salts could be explained with the help of Mukherjee's postulate of the electrical double layer associated with a colloidal particle. According to this theory, some of the counterions are osmotically active while others are osmotically inactive. By careful manipulation and patient experimentation, Dr Chatterjee could find out the critical concentration of potassium chloride which could not only distinguish the two categories but also enabled him to separate them and analyse them quantitatively by means of electrometric titration.

Dr Chatterjee was eventually drawn into the mainstream of soil colloid studies which were actively being pursued in the laboratory of Professor J. N. Mukherjee.

His first exposure to soil research was in connection with a comparative study of some well-known methods of mechanical analysis of soil sponsored by ICAR. Aware of the exceptional skill and meticulous care with which Dr Chatterjee handled analysis of all kinds, Professor Mukherjee entrusted him with this work. In the course of his painstaking work, he devised a simple method of his own, which was based on the dispersive ability of sodium ferrocyanide on soil clays.

The most extensive work carried out by him in the field of soils, refers to the study of clays and clay minerals isolated from, particularly, West Bengal soils. The electrochemical part of the work was an extension of that done on silicic acid sols, which formed the basis as it were. But a complex situation is faced in the case of soil clays and clay minerals. This refers to the liberation of aluminium from acid soil clays, the mechanism of which was not properly understood. By means of carefully designed experiments carried out to study the interaction of acid clays with salts and bases, Dr Chatterjee could unravel the mechanism. He demonstrated that aluminium ions were not formed by any dissolution process as believed earlier, but were exchanged from clays for other cations particularly hydrogen ions. Repeated conversion of the clays into the acid form and treatment with salts brought gradually less and less aluminium ions into solution, and after several such treatments the concentration of liberated aluminium ions was negligible. He could establish a relationship between the amount of exchange acidity i.e. hydrogen ions liberated, and aluminium ions liberated in the process. In fact, the acid clays were not pure hydrogen ion exchangers, but hydrogen-aluminium ion exchangers. This concept was later confirmed and developed by other workers.

Soil clays are usually mixtures of several clay minerals, one of which generally predominates, but the influence of one mineral on the behaviour of others may be considerable. Dr Chatterjee observed that the electrochemical properties of mixtures were not always additive and the mutual influence was sometimes appreciable. The distinctive features of clay, which are aluminosilicates, from mixtures of silicic acid and aluminium hydroxide sols were also established by him.

In building up what is now known as the Calcutta School of Soil Colloids headed by Professor J. N. Mukherjee, Dr Chatterjee played a key role. It was established by this School that electrochemical measurements supplementing those of X-ray, Optical (petrographic) and Differential thermal analysis provide adequate information for identifying the clay mineral make-up of soils. Dr Chatterjee and his research students took advantage of these techniques and began a series of systematic investigations on the clay mineral composition of Indian soils on a profile basis. This scheme was financed by the ICAR, and was to continue further in view of the value and importance of the contribution. But following Dr Chatterjee's death, the scheme had to be terminated.

The soil ingredients are conveniently divided into inorganic and organic. The silicates and other metal oxides which constitute the inorganic part represent the bulk of the soil. The organic part is usually a small fraction and may vary from 0.1 or less to 10% or higher in peaty soils. Even though small in quantity, the influence of organic matter in modifying soil properties is not inconsiderable. But adequate information on soil organic matter was not known at that time. It is equally, if not more, complex than the silicates. Dr Chatterjee began to investigate the colloidal properties of soil organic matter, also called humus, by means of the same techniques as were applied to understand the silicic acid and clay sols. He could thereby establish the existence of lyotrope series in the interaction of colloidal humus with salts and bases. A striking similarity between two diverse soil ingredients was thus demonstrated. His researches gave an impetus, so to say, to a more vigorous study of soil organic matter by some of his colleagues in the laboratory.

Dr Chatterjee also initiated the measurements of ion activity by means of clay membrane electrodes, a technique which he had acquired in the laboratory of Professor Marshall. He showed that the free energy of monovalent cations in homoionic clays was much higher than that of bivalent cations, and that amongst the cations of the same valence, the variations follows the rule of lyotropic series. He used the clay membrane electrodes to measure activity of copper ions in very small concentrations, showing how this trace metal cation in soil could be determined. This line of investigation also sparked off a number of studies by some of his colleagues on the electrochemistry of clay mineral membranes and resin membranes and of many interesting measurements in the field of analytical chemistry by using these membrane electrodes.

At the University of Madison, Wisconsin, Dr Chatterjee worked for several months in the laboratories of Professors Truog and Jackson, and obtained a first hand knowledge of the problems of soil fertility and crystalline forms of soil clays. On the basis of his work there, he published a joint paper on the behaviour of clay minerals under the electron microscope. He continued similar investigations at the University of Cornell, another very well-known centre for soil research.

The second most important phase of Dr Chatterjee's research career opened up soon after he joined in 1949 the Bengal Engineering College. There he continued his researches on soils and soil colloids but at the same time he began to develop the following lines of investigation : (*i*) corrosion of metals and alloys by soil and its remedy; (*ii*) study of the catalytic decomposition of carbon monoxide in presense of metals; and (*iii*) decarburization and dephosphorisation of cast iron alloys by gaseous hydrogen. In each of these investigations, Dr Chatterjee left the impress of an astute physical chemist and a cautious experimenter.

His work on the cathodic protection of mild steel and cast iron against soil corrosion by the use of sacrificial anodes made of aluminium alloys was a significant contribution.

The role of catalysts, such as iron, cobalt and nickel in the decomposition of carbon monoxide, the mechanism of the reaction, possible inhibitors etc are questions of great metallurgical interest. They were thoroughly studied by him and the results were published over a period of eight years in a number of papers. Of similar metallurgical interest was Dr Chatterjee's systematic work on decarburisation and dephosphorization of cast iron and alloys by hydrogen, which included study of their mechanisms, and more particularly the role of moisture in the reactions.

Good portions of Dr Chatterjee's contributions in the field of soil colloids and clay minerals, especially those concerned with their physical and physicochemical properties have found place in standard publications such as the following :

(*i*) *The Colloid Chemistry of Silicate Minerals* by C. E. Marshall, Academic Press, 1949.

(*ii*) *The Clay Minerals* by R. E. Grim, McGraw-Hill, 1954.

(*iii*) *The Physical Chemistry of Silicates,* by W. Eitel, The University of Chicago Press.

(*iv*) *The Colloid Chemistry of Silica and Silicates* by R. K. Iler, Cornell University Press.

The work on gas-metal reactions has been reported in Metal Progress (1950) as important contributions to metallurgy.

Research Guidance and Teaching

Even as a research assistant in the Department of Chemistry at the University College of Science and Technology, Calcutta, Dr Chatterjee was called upon to take classes with post-graduate students and assist them in their thesis work. He was asked to deliver a course of lectures on electrochemistry of clay and clay minerals to graduate students at the Universities of Madison, Missouri and Cornell, USA. As Physical Chemist at the Indian Agricultural Research Institute, New Delhi, he taught post-graduate students Physics and Chemistry of Soils and Clays. The longest and most sustained teaching was done at the Bengal Engineering College where he gave courses on physical and inorganic chemistry and electrometallurgy.

Personal Life and Qualities

In all his capacities, Dr Chatterjee used to assist and advise a large number of students in their thesis work. Starting from 1949 when he joined the Bengal Engineering College, he began to guide Ph.D. students, and about two dozen got their degrees working directly under his guidance.

To the new entrants to Professor J. N. Mukherjee's laboratory Dr Chatterjee was a great source of inspiration. Not only were they initiated by him to the mysteries of research but his personal dedication and behaviour were also worth emulation. They wondered at his performance in the laboratory and tried to imbibe the meticulous care with which he designed his experiments and carried them to successful completion. Because he was a very cautious worker, he valued his experiments highly and as such would not waste time on doing anything redundant. He used to analyse of problem very carefully before he set out to plan the minimum number of experiments which he considered crucial. He hated to do random experiments or shooting in the dark as some were wont to. As a teacher, he gained an enviable popularity amongst students, not only in the class but also outside it. His doors either in the laboratory or at his residence were always open to his students. To them he was an affectionate person having an infinite store of forgivness.

It was his many inimitable personal qualities which made him so attractive to all who came in contact with him. To the extent he was serious in his academic and scientific pursuits and in attending to his responsibilities he was indifferent to affairs mundane, especially when they concerned himself. In spite of his great erudition and high position, Dr Chatterjee was always a modest person and felt shy in accepting honours and laudatory remarks about himself and his work. He fulfilled his ambition to lead a simple, quiet and honest life and to this end he stoically avoided coming to limelight. In his death we have undoubtedly lost a scientist of great promise. Those who came in contact with him from whatever walks of life could not remain unattracted by the touch of his golden heart.

Saturday, December 9, 1967 was the fateful day. It began like any other day. Dr Chatterjee took his morning classes, attended to his official duties, witnessed on his way home students' sports and exchanged pleasantries with his students and colleagues. After a hurried lunch he was getting ready at 1.30 to leave for the laboratory, when he suddenly felt dizzy and fell down on the floor and asked his servant to call for medical help. It was a case of cerebral thrombosis and all possible aid was of no avail. The end came nine hours fifteen minutes later, in the night.

Dr Chatterjee left behind his wife, Dr Asima Chatterjee, the celebrated organic chemist and Ex-Khaira Professor of Chemistry of the University of Calcutta and only daughter Dr (Mrs) Julie Banerjee, receipient of several academic awards including the Young Scientists' award of the Indian National Science Academy, and at present lecturer in Chemistry, University of Calcutta. The son-in-law, Dr Avijit Banerjee, also a brilliant chemist, is a reader in the University of Calcutta.

Research Publications

A list of his publications is appended, which has been arranged in accordance with the broad subjects of research topics. It was characteristic of Dr Chatterjee to use Indian journals for publication of his papers. He followed this principle assiduously and urged upon others to do so, believing that it was no less prestigious than publishing in foreign journals, and that this practice was one of the means by which the standard of our journals could be raised.

S. K. Mukherjee
Asima Chatterjee

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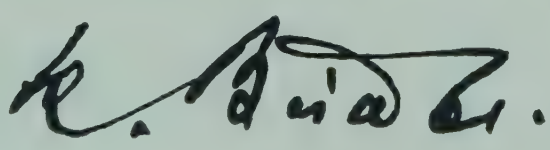
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KALIPADA BISWAS

(1899–1969)

Elected F.N.A. 1950

Early Life and Education

Kalipada Biswas, a renowned botanist of India, came from a respectable family of Burdwan District in West Bengal. He was born on December 3, 1899 in Calcutta and was the second son of the late Shri and Smt. S. P. Biswas. He spent his childhood at Beltala in Bhowanipur in Calcutta. In School, he was good in Sanskrit and secured the highest marks in his class. Biswas passed the Matriculation Examination in 1916 from the Mitra Institution, Bhowanipur Branch and was a contemporary of the late Dr Shyama Prasad Mukherjee. He was in the first batch of students of Bangabasi College. He passed the Intermediate Examination in 1918 with Botany as one of his subjects. In 1920, he graduated from Bangabasi College. Biswas was a student of Drs S. P. Agharkar, S N. Bal, S. C. Banerjee and G. C. Bose.

Research and Career

In 1922, Dr Biswas took his M.A. Degree in Botany, securing first class first from the University College of Science and Technology, where his classmates were Professor I. Banerjee, Professor A. C. Dutta, Shri S. C. Nag, the first two later became well-known teachers of Botany. At this period, he came in contact with Professor Paul Johannes Brühl, who developed in him an interest in algae. His first paper was on algae of Bengal filter-beds (1922). From 1923 onwards till 1932, he published several papers on algae, such as Algal Flora of Chilka Lake, the Road Slimes of Calcutta, Flora of Salt Lake, Calcutta, etc. During the years 1923–26, he worked as a research scholar in a scheme sponsored by the Government of Bengal, but continued to work in several disciplines of systematic botany, especially on algae. The year 1927 was significant, when he was appointed Curator of the Herbarium of the Royal Botanic Gardens, Calcutta. In 1936, Biswas went to England and as a result of his extensive studies in the Kew Gardens, in the British Museum and in Edinburgh under the guidance of Sir W. W. Smith, F.R.S., he was conferred the D.Sc. degree of the Edinburgh University in 1937. In 1937, he became the first Indian Superintendent of the Gardens. In addition, a part of the responsibilities of the Director of the Botanical Survey of India was assigned to him. He made a thorough survey of the algal flora of the Salt Lake in Calcutta and of the Chilka Lake in Orissa. He also studied the vegetation of

Burma and various parts of Eastern Himalayas for a period of 25 years. Dr Biswas was the first Indian who worked and published original findings on Indian diatoms and Iron bacteria (1937).

Biswas and the Botanic Gardens

Dr Biswas remained Superintendent of the Botanic Gardens for 17 years. He strove all through this period to maintain high academic and administrative standards. His ambition was to see that the Gardens attain the same status as the other well-known botanical gardens of the world.

He made extensive collections of plants from India and neighbouring countries; these resulted in the publication, "The distribution of wild conifers in the Indian Empire" (1933), "Glimpses of vegetation of south Burma" (1933), "Some foreign weeds and their distribution in India and Burma" (1934), "Studies in ferns and fern-allies in Burma" (1935), "Handbook of common water and marsh plants of India and Burma" (1937), and "Systematic position of a common tree fern of the eastern Himalayas with a note on the genus *Cyathea*" (1943).

The valuable specimens collected by him from Nagaland, Tripura, Manipur, Orissa, Bihar and Sikkim and also from South Burma are housed in the Central National Herbarium (Calcutta). He had a special interest in the plants of Sikkim Himalayas, a region which he explored extensively. These have been recorded in his "Common plants of Northern Sikkim" (1936), "Common medicinal plants of Darjeeling and the Sikkim Himalayas" (1956), and in a voluminous work entitled "Plants of Darjeeling and the Sikkim Himalayas" (1966). Dr Biswas was also among the pioneers in botanizing Tripura.

Director, Medicinal Plants Scheme, West Bengal

After his retirement from the Indian Botanic Gardens, Howrah, in 1955, Dr Biswas was appointed Director, Medicinal Plants Scheme, Government of West Bengal. At that time, the cultivation of the medicinal plants, *Rauwolfia* and *Ipecac,* had just began and Dr Biswas remarked : "*In the applied aspect, I had the chance of developing cultivation of medicinal and aromatic plants and in fact, developed Ipecac plantation which proved to be the largest in the world. The roots produced are now meeting not only our internal consumption but also earning foreign exchange.*" Detailed accounts of the cultivation of these two plants were published in 1956 and 1958 re,pectively.

As Emeritus Scientist of the CSIR

Dr Biswas retired in December, 1964 from the Office of the Director, Medicinal Plants and continued his researches as Emeritus Scientist of the Council of Scientific and Industrial Research in the Botany Department, University College of Science and Technology, Calcutta, till the last day of his life. Since 1940, he was Honorary Lecturer in the same Department. He used to teach Algae to the Post-Graduate Classes. His lectures were very interesting.

In a lecture, Dr Biswas remarked : "*As a student and teacher I am, therefore, in a position to advise the younger generation that they should be true to themselves and devote whole-heartedly to the subject of study in which they are interested. If a student acquires sufficient sound knowledge in a particular subject and follows the righteous path, he will undoubtedly be able to stand on his feet by the blessings of God. Therefore, work devoted with Heart within and God overhead.*"

Honours

As a teacher of repute, Dr Biswas earned the esteem and affection of his students and colleagues. He received wide appreciation of his life-long and devoted research in several branches of Botany Several institutions awarded him medals and prizes. He received the '*Coronation Medal*' in 1937 for meritorious public services. He was twice awarded the '*Elliot Gold Medal*' and a cash prize. He was also awarded the '*Paul Johannes Brühl Memorial Medal*' in 1952 by the Asiatic Society and in the same year he received (jointly with Shri Akkari Ghosh) the *'Rabindra Prize'* in science for the work entitled *'Bharatiya Banaushadhi'* (3 Volumes).

Dr Biswas was President of the Section of Botany, Indian Science Congress, in 1943. His Presidential address, 'Systematic and taxonomic studies on the Flora of India and Burma' remained the main source of information on the taxonomy and plant geography of India for a long time. He was elected Life Member of the Asiatic Society of Bengal on August 1, 1923. He was President of Botanical Society of Bengal during 1948–50, 1960–62 and 1969 and President of the Indian Botanical Society in 1952. He was elected Fellow of the Royal Society, Edinburgh, National Institute of Sciences of India (1950) and Society de Botanik of Paris.

Dr Biswas was connected with various other educational and scientific organisations in India, like the Indian Council of Agricultural Research, Central Indian Medicinal Plants Organization, Organon (India) Ltd., Bhabha Atomic Research Centre and National Botanic Gardens.

In 1954, Dr Biswas was selected as one of the four delegates of the Government of India to represent India at the Agricultural Exhibition in Moscow. In the same year, he visited several Botanical and Agricultural Institutions in Europe. Dr Biswas took a leading role in the revival and reorganisation of Botanical Survey of India.

Dr Biswas died on December 29, 1969 at his Ballygunge residence in Calcutta, after a prolonged illness. He left behind his wife, two sons, Professor Sanat Biswas (Bengal Engineering College, Howrah) and Dr Sanjib Kumar Biswas (Oil and Natural Gas Commission) and a daughter. One daughter predeceased him.

Acknowledgements

The authors are grateful to Professor B. C Kundu and Sanat Biswas for providing some informations about Dr K. P. Biswas.

S. K. Jain
R. N. Banerjee

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P. La Guardia

PIARE LAL SRIVASTAVA

(1898–1970)

Elected F. N. I. 1935

PIARE LAL SRIVASTAVA, a brilliant student, an eminent mathematician, a specialist in the field of 'Theory of Functions' was an organizer, administrator and educationist of the highest order. A brilliant teacher, he was intimately acquainted with problems pertaining to research, teaching and administration in the country.

CHILDHOOD AND EARLY EDUCATION

Piare Lal was born the son of Munshi Jeorakhan Lal on February 11, 1898, in village Uttha of Tehsil Billaur in Kanpur district, U.P. He started his formal primary education at Hathgaon. His teacher at the Town School, Hathgaon saw his brilliance and potentiality and advised his father to shift him to the district town of Fatehpur where he studied in the Government High School up to the matriculation stage. He passed the matriculation examination of Allahabad University in 1915 in first division. He was a Government Scholar having passed in first division with distinction in Mathematics in the Vernacular Final examination in 1910 and having topped in U.P. at the High School Scholarship examination in 1913. In 1915, he joined the Kayastha Pathshala Intermediate College at Allahabad and subsequently passed the Intermediate examination in 1917 in the first division.

Principal J. Sen, his mathematics teacher at K. P. Intermediate College, writes : "*As an old teacher of his, I can still remember P. L. Srivastava sitting in my classes and displaying amazing aptitude for the study of Mathematics which distinguished him from his dim contemporaries at College. In natural intelligence, quick grasp of principles and his capacity of tackling the most baffling problems, he outshone all his fellow students.....*"

UNIVERSITY EDUCATION

Muir Central College of Allahabad University was a renowned educational centre which attracted brilliant students from all over India. Young Piare Lal Srivastava joined the B.A. first year class at Muir Central College in 1917. He passed the B.A. Examination of Allahabad University in 1919 and obtained first division and first position, breaking records in Mathematics.

He selected mathematics for his post-graduate studies and got first division first position at the M. A. (Pre.) examination in 1921 and then topped at the M. A.

(Final) examination in 1922. In recognition of his brilliant academic performance, the Allahabad University awarded him the '*Homersham Cox Gold Medal*' for standing first in Mathematics at the combined B.A. and B.Sc. examination of 1919 and the '*Queen Empress Victoria Jubilee Medal*' for standing first in the combined M.Sc. examination of two consecutive years 1921 and 1922.

Teaching, Research and Scientific Activity

The University of Allahabad appointed him as Lecturer in Mathematics in August 1922. The State Government offered him the post of a Deputy Collector which he declined in order to pursue academic activity. Within three years, he was awarded a Government scholarship for higher study in England and he joined the New College of Oxford University in September 1925 to do research under the eminent Mathematician Professor G. H. Hardy. In a record time of two years, Piare Lal Srivastava submitted a thesis on '*Theory of Functions of Complex Variable*' which was examined by Professor E. G. C. Poole and G. N. Watson. He was awarded the D. Phil. degree in 1927 by the Oxford University on this brilliant work. Some of his research papers made a notable contribution to our mathematical knowledge, and passed through the hands of such distinguished mathematicians as Professor Hadamard of France and Professor Littlewood of Cambridge. Dr Srivastava's papers published in *Comptes Rendus and Bulletin Societe Mathematique des France* were communicated by Professor Hadamard. Professor Titchmarsh of Oxford paid rich compliments to him while reviewing his work in "*Science Progress*" of July 1929 and included one of his papers in his book "*Introduction to the Theory of Fourier Integrals*" published in 1937.

Dr Srivastava returned to India and continued his teaching and research activity at Allahabad University. He was an excellent teacher, known for his clarity of thought and expression and more so for his capacity to solve any problem in a most relaxed manner. He was appointed Reader in Mathematics at Allahabad University in 1929. In February 1950, he was appointed a temporary Professor of Mathematics and in July 1952, he took over as a permanent Professor and Head of the Mathematics Department in the University of Allahabad. He organized the teaching and research in the Department very effectively. In view of his popularity, he was requested to shoulder the responsibility as Dean of Student Welfare from 1958 to 1960.

Honours

He was elected Fellow of the National Institute of Sciences of India in 1935. Dr P. L. Srivastava was a close associate of Professor Meghnad Saha and was associated with the National Academy of Sciences, India, to which he was elected Fellow in 1931. He served as its Hon. General Secretary from 1935 to 1938 and again from 1945 to 1948. He was President of the Academy from 1955 to 1957. He delivered the Presidential Address at the Silver Jubilee Session of the National Academy of Sciences in December 1955 on "*Dirichlets' Series*". He again presided over the 26th Annual Session of the National Academy of Sciences in February

1957 at Aligarh and delivered the Presidential Address on *"Theory of Functions and allied topics."* The National Academy of Sciences received his guidance and support throughout his life time.

Family Life and Personal Qualities

Having lost his mother when he was hardly six months old, Srivastava spent his early life with his uncle, aunt and father besides his elder brother, Sri Gajadhar Prasad and a sister. Living in a joint middle class family, he developed qualities of simple living, tolerance and adjustment.

In 1921, he was appointed personal tutor to the Raja Saheb of Korea, a princely state of the Central Provinces and Berar It is during this assignment that he met Shyam Kumari Srivastava, daughter of Munshi Raghubir Prasad, who was the Superintendent of Korea State and later became the Dewan of Kanker State. Piare Lal Srivastava married Shyam Kumari in May 1922. *"Mem Saheb"* was a source of great strength to the happy family consisting of four sons Prabhat, Sushil, Rajendra and Ajit and one daughter Pratibha. Sushil was a Lt. Col. in the Army and the other three sons are highly placed business executives. Dr Srivastava was a very successful social figure. His serene and ever smiling countenance attracted a number of friends. He did not lose his temper under the most provocative circumstances. His capacity to argue a case and persuade others to accept his point of view was his biggest asset. In recognition of his academic brilliance and service to society, he was given the title of *Rai Saheb* in 1939.

Educationist, Organizer and Administrator

As an educational organizer, Dr Piare Lal Srivastava took active interest in the affairs of the Kayastha Pathshala, a premier educational trust of North India, founded by the Late Munshi Kali Prasad Kulbhaskar in 1873. In 1950, he took charge of the Kayastha Pathshala as its Receiver and immediately embarked upon a programme of educational expansion. He noticed that a large number of students who wanted to pursue the study of Sciences at the Degree level were unable to do so due to limited accommodation in the University. He planned degree college under the K. P. Trust primarily for teaching B.Sc. classes and succeeded in starting the Chaudhaary Mahadeo Prasad degree college associated with the University of Allahabad. This college now teaches B.A. B.Sc., B. Com., and LL.B. classes and is the largest Associated college of the University. In 1952, Dr Srivastava was elected to the High office of the President of Kayastha Pathshala. He remained President of this great institution from 1952 to 1956, from 1962 to 1966 and again from 1967 till he expired after a brief illness on July 13, 1970. During his tenure, he upgraded the Agriculture College to postgraduate level, affiliated to the Kanpur University and started a training college, besides a Girls's school. It can easily be said that Allahabad owes a great deal to Dr Srivastava because it is due to his foresight and determined efforts that Kayastha Pathshala today provides educetion to a large number of studerts in science, agriculture, arts, commerce, law and education in its many institutions. His devotion to duty and precision in thinking

were among other qualities, responsible for his success in the educational organization.

He served the cause of education as member of the Legislative Council of the State of Uttar Pradesh also. He remained a Member of the Council for about ten years representing graduates and teachers. In this capacity he took active part in several educational legislations.

He showed excellent administrative capability in the field of education when he worked as the Vice-Chancellor of Bihar University, Muzaffarpur from 1962 to 1965. His contribution to the development of Allahabad University, while working as member of its Executive Council, court and other bodies is well known.

Acknowledgement

The help received in preparing this memoir from his wife, Mrs Shyam Kumari Srivastava, his second son Lt. Col. Sushil Kumar Srivastava and his old student Professor Harish Chandra Khare is gratefully acknowledged.

Krishnaji

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BIBHU BILAS BHOWMIK

(1907–1970)

Elected F.N.I. 1959

Birth and Education

Sri Bibhu Bilas Bhowmik was born on October 10, 1907 in Shyrmnagar, District Nadia, West Bengal. He was the only child of Baman Das Bhowmik and Sarat Kumari Devi. His father passed away when he was two and his mother when he was ten. He went through much hardship right from his childhood, and had to go over to Arrah in Bihar to live with a relative. After passing the Matriculation examination from Arrah Zilla School in 1924, he joined the Patna Science College. While studying for his B.Sc. examination he took up a part-time job at the Patna Medical College, serving as Technical Assistant to Capt. P. B. Mukherjee, the well-known Radiologist.

Interest in X-Ray Engineering

The opportunity of handling various types of X-Ray machines at such an early age inspired Bhowmik to pursue the study of X-Ray Engineering in his later life. Right from his youth, he cherished the dream of manufacturing scientific instruments and planned his career accordingly.

After taking his B.Sc. degree, he entered the M.Sc. Physics class of the Patna University and also continued his service at the Patna Medical College. His chief, Capt. Mukherjee, was kind enough to adjust his duty hours according to the Post-graduate schedule.

In 1931, Bhowmik came to Calcutta and joined the Applied Physics Department in the University College of Science as a Post-Graduate student. Applied Physics was his subject of preference because it introduced him to high voltage systems, so essential for the study of X-ray Engineering. Here, he came in contact with eminent scientists like Professors P. N. Ghosh, S. K. Mitra and M. N. Saha. He proved to be a worthy student and his talents were recognised by Professor P. N. Ghosh, the then Head of the Department of Applied Physics.

After taking his M.Sc. in Applied Physics in 1933, he engaged himself as a trainee under Professor L. G. Vimar, the well-known French X-Ray Engineer of those days. In 1934, Bhowmik proceeded to England with a Guru Prasanna Ghosh Travelling Fellowship to join the Queen Mary College of the London University, where he worked under Professor McGregor Morris in the Department of Electrical



B. B. Bhowmik

Engineering. He secured his M.Sc. (Engng.) degree in 1937; meanwhile during vacations he underwent practical training in several well-known firms manufacturing X-Ray equipment.

Pioneer in X-ray Equipment

His ambition was to establish an X-Ray equipment manufacturing firm of his own in India and he never deviated from this ideal. Even when he was offered a lucrative job by Westinghouse in U.S.A. and subsequently to become the Chief X-Ray Engineer of Westinghouse in India, he declined the offer. Instead, he accepted a research scholarship by the French Government to work under the famous French High Voltage Engineer, Professor Pauthenier. Bhowmik collaborated with him in designing the famous Pauthenier High Voltage Generator and also worked on different models of van de Graff generators. He was undertaking training in different High Voltage Institutions in France and Germany when the Second World War broke out.

Bhowmik had to give up all research and practical training and return home. The situation in Europe rapidly worsened and the return journey by sea route was frought with danger. So, he travelled halfway across Europe and Asia Minor by the land route passing through Turkey, Damascus, Baghdad etc. He arrived safely in Calcutta in September, 1939.

Professional Career

He took up a new challenge in his professional career. Instead of accepting a teaching or research position in a University, for which he was eminently qualified, he started on his own a small workshop for developing scientific instruments. Nationalist leaders like Syama Prasad Mukherjee, Dr B. C. Ray and scientists like Professors M. N. Saha and S. N. Bose lent him support in this venture. Dr B. C. Ray offered him the job of Visiting X-Ray Engineer of all the Hospitals in West Bengal and Shri Bhowmik also occasionally delivered lectures on High Voltage Engineering at the Applied Physics Department in the Calcutta University.

A research scheme for the study of permanent magnets and magnetic materials under his guidance was granted by the C. S. I. R. His efforts in research and development soon bore fruit.

A Faradic precision electro-medical instrument and other types of machines for Physiotherapy were developed for the first time in India. These machines were very useful to the country because they could serve the defence departments during the War. Within a few years, Bhowmik made a remarkable contribution in the field of High Voltage Engineering. He manufactured High Voltage Transformers with indigenous materials and this led to the foundations of X-Ray Industry. He was a pioneer in manufacturing X-Ray Equipment in India.

His achievements received recognition all over the country. Sir C. V. Raman visited his workshop and was so impressed that he mentioned in one of his lectures that he had seen in Calcutta X-Ray machines being fabricated in a little hut.

In the pre-Independence days indigenous products had to face stiff competition. In spite of these difficulties, Shri Bhowmik's X-Ray machines found a market all over India. He underwent heavy financial difficulties and immense strain to pursue his ideals but never deviated from them.

In the field of academic research, his transformers found wide application, X-Ray diffraction machines which were being imported from abroad were fabricated by him. Researches on X-Ray crystallography and electron-diffraction became more productive due to easy availability of X-Ray Units in India. Several electron diffraction units were set up using his high voltage power supply which were found useful in various branches of Physics, Chemistry, Engineering Sciences and in Testing Laboratories.

Honours

He was rewarded with honours within a few years. The Indian National Science Academy elected him a Fellow in 1959. The Indian Science Congress elected him the Sectional President of the Engineering and Metallurgy Section in 1955. In a book on the International History of Development of X-Ray Industries entitled *The Trail of Invisible Light* (*Ed.* : E. N. Grigg), his pioneering efforts in the field of X-Ray Engineering in India found appreciation.

As pioneer founder of high voltage priority industry in India, Shri Bhowmik will be remembered throughout the country for generations. His development of technical knowhow for high voltage instruments is still an inimitable achievement.

Marriage and Family Life

In 1931, Shri Bhowmik married Smt Saroma Devi, who in later years became well known to art lovers of Calcutta as a distinguished painter. His only daughter, after securing a Doctorate in Physics with specialisation in X-Ray Crystallography, became actively involved in her father's enterprise.

In 1969, Shri Bhowmik went to Japan and made a tour of various centres in U.S.A. and Europe to gather experience in the latest advancements in his field of interest. He returned home in early 1970, after a successful mission, radiant with high hopes of infusing new vitality to the indigenous X-Ray industry of India. But it was destined otherwise. He fell ill shortly afterwards, and the doctors diagnosed cancer at an incurable stage. The end came on December 18, 1970 with many a dream unfulfilled, and his daughter took up the responsibility of continuing his unfinished work in the field of indigenous manufacture of X-Ray equipments in India.

Gouri Ray

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RAJNATH

(1904–1972)

Elected F.N.I. 1943

Birth and Parentage

Rajnath was born on August 8, 1904 in a middle class family. He was the third of six children of his parents—Dr Ayodhya Prasad and Smt Premvati Devi—who were religious and god-fearing. The father was a physician, devoted to his profession with a missionary zeal and to the service of suffering humanity without any consideration of material gain. His spirit of dedication left an indelible imprint on the mind of the impressionable young son. In his fourteenth year, Rajnath lost his father; but his mother, with the help of an elder brother, brought him up with great care. An orthodox housewife, she also took interest in the welfare of those associated with the family. She had the good fortune to see her talented son become a well-known geologist.

Education

Young Rajnath had his early schooling, up to the Upper Middle stage (Class VIII), at Mandawa under the local guardianship of Thakur Inder Singh. He passed the Matriculation examination of the U.P. Board in 1920 as a student of Nanak Chand Anglo-Sanskrit High School at Meerut. Soon after, the family shifted to Nagina. This posed the problem of Rajnath's higher education in a college. The choice fell upon the then new Banaras Hindu University whose founder was Pandit Madan Mohan Malaviya. In July 1920, Rajnath entered this national institution and passed the I.Sc. examination in 1923. Two years later, he took the Bachelor's degree with Botany, Geology and Chemistry.

Dr L. Dudley Stamp, a geographer of world-fame and then Professor and Head of the Department of Geography and Geology in the University of Rangoon, Burma, happened to visit the B.H.U. He was much impressed by the simple and unassuming young Rajnath and offered him a position in Geology at the University of Rangoon with the facility of doing his M.Sc. there. It was indeed a timely offer which could substantially ease the burden on Rajnath's family resources. But in deference to the wish of Rajnath's mother and elder brother, the offer was declined and Rajnath continued in B.H.U. and obtained his M.Sc. degree in Geology there in 1927.



As a post-graduate student at Varanasi, Rajnath availed himself of the benevolent care and guidance of Professor Krishna Kumar Mathur, a Foundation Fellow of the Indian National Science Academy, and a pioneer in Geology in India. Professor Mathur was a *guru* and *acharya* in the true sense of these terms and Rajnath, throughout his life, dedicated himself to the sacred duty of becoming his true disciple. The ties between the *guru* and the pupil grew stronger with the passage of time.

Impressed by his diligence, devotion to studies, keen observation in the field and aptitude for research, and with a view to strengthening the Department in various sub-disciplines of Geology, Professor Mathur, himself a petrologist, advised Rajnath to specialize in Palaeontology. Accordingly, in the summer months, following his M.Sc. examination, Rajnath began detailed field investigations on the Jurassics of "Western Kutch." Early in 1928, Rajnath sailed from Bombay and in February that year he joined the Imperial College of Science and Technology, London, for training under the well-known British Palaeontologist, Dr A. Morley Davies, and Professor W. W. Watts, a renowned Professor of Geology. Both these teachers were highly impressed by the diligence and dedication of their Indian pupil, his methodical and meticulous work, and his excellent fossil collection.

Two years later, he obtained the Ph.D. degree of the University of London as well as the Diploma of the Imperial College (D. I. C.) on his thesis, "Palaeontology and Stratigraphy of part of Cutch State," which was based only on a portion of his research material. Dr Rajnath had made a significant contribution to the geology of this region of India.

Professional Career

While in London, Dr Rajnath had planned to continue his research work further, but events in India took a sudden turn. Professor Mathur contracted a rare blood disease. The fast deteriorating health of his revered teacher compelled Dr Rajnath to return to India to join the staff of the Department of Geology of his *Alma Mater*. He was appointed Assistant Professor of Geology in the leave vacancy of Professor Mathur in September, 1930.

Simultaneously, India was in political turmoil. Malaviyaji was imprisoned. The University was in crisis and there was the threat of stoppage of government aid. Professor Mathur cancelled his leave. Consequently, Dr Rajnath agreed to serve the University without salary for several months until he was appointed Assistant Professor of Palaeontology in July, 1931.

Five years later, in July 1936, Professor Mathur died prematurely and the responsibility of administering the Department fell on the young shoulders of Rajnath who nursed the Department of Geology as its Head for over three decades. During this long period, Dr Rajnath gradually rose to the rank of University Professor of Geology and Geography. He also occupied the Chair of the Principal of the College of Science from May 1, 1960 till his retirement in June, 1967. After retirement, he worked under the University Grants Commission scheme of retired teachers from March, 1968 to December, 1970. He continued

to visit the Department now and then and hold discussions with the research team working on the Jurassics of Kutch.

During his tenure in B.H.U., he taught Geology for a few years (in the summers of 1930s) to the engineering students of the erstwhile Thomson Engineering College, which later grew into the present University of Roorkee. Again, in the summer of 1951, he accepted a similar assignment at the request of that University with the assistance of the present author. Industrialists, engineers and geologists (including his own students) had frequent and free consultations with him on their problems and took advantage of his experience and expertise.

Dr Rajnath was an illustrious alumnus of the Banaras Hindu University which he served for nearly thirty-six years with selfless devotion, sustained hard work, exemplary zeal and ability in various capacities. Inspired by Malaviyaji, by Professor Syama Charan De (who with self-abnegation served successively as Head of the Department of Mathematics, Principal of Central Hindu College, Registrar and Pro-Vice-Chancellor), and by his own talented *guru*, Professor Mathur, Dr Rajnath remained attached to this great institution throughout his career. Lucrative offers carrying attractive emoluments from industry came his way, but could not move him away from University teaching and research.

A Geologist

Professor Rajnath always impressed on his students that Geology was essentially a field science and that field investigations were as essential as, at times even more important than, laboratory studies : *"One cannot know well the geology of a country (region), howsoever small it be, if one has not lived there for long time; one must sleep, dream and even suffer the vicissitudes of the weather on the rocks which one wishes to study."* (J. Marcou, translated by the present author).

Collection and organization of field data are of fundamental importance for the study of earth-history. Geological theories can only be verified, sifted and tested by evidence supplied by the rocks themselves exposed in the field. Professor Rajnath, therefore, stressed that one should work in the field with an unbiased mind, and should record the observations truthfully; for the natural facts are unchangeable even though the readers may interpret them differently.

He followed and emphasized the excellent geological counsel, "*Go and See* !" Even in Kutch, where he had worked extensively, he never allowed the present writer and Brahma Swarup Tewari (later Professor and Director, Centre of Advanced Study in Geology, Panjab University, Chandigarh), to take for granted what he told them. Any explanation or conjecture put forth by him in advance (from a distance) was invariably followed by the directive : "Let's go and see !" One day both these students were very much tired on account of long hours of work under scorching heat and heavy load of specimens, when the Professor referred to the occurrence of a particular bed at the top of a hill. Structurally there was hardly any scope for doubt but still he wished them to climb up the steep slope (which they reluctantly did despite hunger and fatigue) to ascertain the bed number in the sequence. On such occasions of weariness and despondency, Professor Rajnath recalled the *guru-mantra* he had learnt from Professor Mathur:

"*Walking another mile would not kill us.*" These words, indeed, toned up the sagging spirit and infused a new vigour and strength in us.

Further, citing anomalies in the stratigraphic conclusions and biozones of two famous British palaeontologists, he advised his students to personally examine and measure the geological sections and collect fossils for constructing bio-stratigraphy of a region. One should not merely work out the collections made by others and make deductions on their basis with preconceived notions. For, in such cases, both systematic identification and stratigraphic interpretation could often turn out to be erroneous. Also, there was the likelihood that one might establish a zone with thickness less than the size of the fossils contained therein.

Professor Rajnath emphasized that in Geology the inferences should be based on regional study rather than on studies in limited area(s). After having personally surveyed the important and major sections (exposures) of "Chari Series," the present author came to certain conclusions by the late fifties and wished to put them in writing. Although Professor Rajnath agreed with them on the basis of his own experience of the entire "Western" Kutch, he suggested to defer publication till the completion of a detailed study of the remaining exposures. It would perhaps be appropriate to mention here that basalt, in the first instance, was considered by Abraham Gottlob Werner and his followers to be a chemical precipitate from a universal ocean on the basis of its occurrence in the Scheibenberg in Erzegebirge. But subsequently Wernerism, when subjected to the "critical test" of extensive field-observations in other parts of Germany, Italy and France, etc., failed and this rock was accepted to be a volcanic product.

Even as a boy, Rajnath had "a flair" for collecting uncommon stones and rocks. While in the field, Dr Rajnath was a keen observer and had a quick eye for finding fossils. He was familiar with a variety of geological terrains of the Indian subcontinent. He had geologically mapped, all alone, the vast exposures of the Jurassics of Kutch Mainland, under very trying conditions, during the period from May to November. On the basis of personal experience in two field trips with him at an interval of several years, it may be said unhesitatingly that he was accommodating, an inspiring guide, untiring and adaptable under all circumstances and an exemplary field geologist. Dr L. F. Spath, F. R. S., of the British Museum (Natural History) acknowledged him as a *"very able geologist and palaeontologist..... (with) great experience in mapping.*"

Dr Rajnath had a keen interest in research and made a mark in his field at a very young age. However, misfortune hit him hard at the very outset of his research career in 1927. The fossil collection he had made during his extensive field work in Kutch was displayed at the Royal Palace in Bhuj in deference to the wish of Maharao Shree Kengarji. This was done with simple-hearted and unsuspecting enthusiasm by the young seeker after truth who had spared no pains to amass that "wealth" from the "treasure" of Jurassic sediments within the "territory of a ruling prince."

Unfortunately, at the instigation of Mr John Hubert Smith, who was Director of Education in the erstwhile Kutch state besides being a tutor to the then Yuvaraj

Shree Vijayrajji, the Maharao Shree banned the movement of the fossil collection out of Kutch. But, to the good luck of Rajnath, the Yuvaraj Shree pleaded with his father that at least the benefit of studying those stones be given to their collector (RN) who had assiduously worked for many months to collect them. Additionally, a telegraphic request from Pandit Madan Mohan Malaviya, the then Vice-Chancellor of Banaras Hindu University, who was highly respected by the Indian princes, had its effect on Maharao Shree. And at last permission was accorded to take out of the territory of Kutch the stones which were to serve as the foundation for a future palaeontologist.

Another disappointment was there in London. For his doctoral thesis, Rajnath had meant to work on the ammonoids, with the object of "establishing a detailed succession of the Jurassic rocks of Kutch, to develop a local detailed faunal time-scale, and also to find out how far the field evidences in India would support the hemerae of Buckman." But his magnificent ammonite collection did not escape the covetous eye of the ammonitologist of the British Museum (Natural History), Dr Spath, who was more or less at the same time entrusted by the Geological Survey of India with the much needed revision of the cephalopod fauna of Kutch. Through Dr Morley Davies he requested for a loan of fossils and got more than 1500 specimens in addition to freely consulting the notes, maps and field observations which Rajnath had made so painstakingly and with such meticulous care. Rajnath had no option but to surrender them and with much disappointment had to remain content with working only on the brachiopods for his Ph.D. thesis. The incident was unforgettable and when a quarter of a century later a similar story was repeated with one of his students in London, Dr Rajnath wrote to him : *"I thought Palaeontology had taken enough sacrifice from me but probably it needs more."*

The episode did not end with the loan of specimens. On his return from Britain, Dr Rajnath wished to publish his conclusions at an early date. A paper was presented before the Geological, Mining and Metallurgical Society of India. But certain officers of the Geological Survey of India, which was manned largely by the British, desired its publication to be withheld, in view of the pending appearance of the concluding part of Dr Spath's Memoir. However, through the kind intervention of Mr D. N. Wadia (later National Professor of Geology) who was then connected with the publication of official memoirs, Dr Rajnath's paper could see the light of the day earlier than the appearance of the British palaeontologist's memoir.

These episodes, particularly the one that took place in London, considerably shocked Dr Rajnath. Sad memories always loomed large over his mind whenever there was talk of research or Kutch Geology. But he never completely lost interest; and though in the later part of his career, he was forced to spend much of his time in administration, he contributed a good deal on research side Nor was this in Palaeontology and Stratigraphy alone: from the bibliography at the end, and doctorate theses supervised by him it will be found that his studies were spread over other sub-disciplines such as Structural Geology, Petrology, Economic Geology (including industrial aspects), Engineering Geology and Hydrogeology.

CONTRIBUTIONS

To begin with, Rajnath's work on the Jurassic rocks of Kutch is a very notable contribution to the geology of India. It has been highly valued by accredited authorities on the subject. *"His research work,"* in the words of Dr A. Morley Davies, *"has shown great industry, accuracy and originality."* It also won him international repute besides honours in his own country.

In addition to mapping the Jurassics of the "Western Kutch" on 1 inch to a mile scale with "*conspicuous energy and skill*" (Professor Watts), Dr Rajnath worked out in detail the stratigraphy of the "Chari Series" of the classic Jumara dome whence an ammonoid collection had been earlier made by Professor J. F. Blake and worked out by Dr Spath. On the basis of his find of a specimen referable to the Palaeozoic genus *Streptorhynchus* King in Jumara Bed No. 22, Rajnath thought of the "possible extension of the Product beds of the Salt Range to some parts of Kutch." Lately, some geologists of the Oil & Natural Gas Commission have felt that the existence of pre-Bathonian sediments in the western part of Kutch basin and in the off-shore region cannot be ruled out.

In his classification of the Kutch Jura, Dr Rajnath introduced important modifications in the upper part of the succession : (*i*) he used the term Umia Series in a restricted sense for Lower Umia of Waagen; (*ii*) he applied the name "Bhuj Series" to the plant-bearing beds, i.e., Upper Umia Group of Waagen including the *Zamia* beds (= Upper series of Wynne); and (*iii*) he regarded the Aptian beds of Ukra hill containing "*Australiceras*" to be older than the Bhuj Series on the basis of structural evidence. These changes have been confirmed by subsequent geological work by Burmah Oil Company and have been adopted by Dr W. J. Arkell in his standard reference book on the Jurassic Geology of the World.

Umia Series (*s. str.*) has been divided by Dr Rajnath into five divisions (in ascending order) : (*a*) Barren sandstones and shales, (*b*) the three Green Oolitic beds (= the Basal Umia Ammonite bed of Dr Spath) which have yielded Tithonian ammonites, (*c*) Barren sandstones, (*d*) *Trigonia* beds, and (*e*) Barren rocks. The Green Oolitic beds to the east of Mundhan (in the extreme northwest of Kutch Mainland) yielded to him a solitary individual of *Stylina,* which extended the range of corals in Kutch upwards into the Tithonian. The Bhuj Series consisting of at least three horizons, *viz., Zamia* beds at the bottom, *Ptilophyllum* beds in the middle and *Palmoxylon* beds at the top, has been assigned to post-Aptian age—not older than Middle Cretaceous, and possibly, slightly younger. In other words, according to Dr Rajnath, the upper age limit of the "Gondwana System" is probably Middle Cretaceous.

He postulated the existence of "Pleistocene beds in the form of at least two big anticlines beneath the Indo-Gangetic alluvium," which run parallel to, and south of, the Himalaya. The finds of *Stegodon* teeth, one specimen each at Prahladpur (about 95km downstream of the river Ganga from Varanasi) and near Agricultural Institute at Naini (Allahabad) have lent support to his view.

Disagreeing with several geologists, Dr Rajnath ascribed an inorganic origin to the conical ring structures found in Fawn Limestone in the district of Mirzapur

(U.P.) and related them to the sink-holes formed earlier than the dolomitization and silicification of the rock.

His detailed investigations on Panjal volcanics, particularly in the vicinity of Srinagar, confirmed Professor Mathur's discovery of acid-differentiation products in them which, additionally, "are not quantitatively so unimportant" as believed by certain geologists.

Apart from his devotion to academic problems, particularly in the field of his specialization, Dr Rajnath was conscious of a geologist's role and obligation in the development of the national resources and the good of mankind. He used to say : "*Nature is bountiful but not limitless.*" He, therefore, stressed proper utilization and conservation of India's natural resources. He was always deeply moved by human sufferings on account of imbalance in hydrological cycle. He was a shocked witness to the havoc caused by the severe floods of 1938, 1948 and 1967 in northern India. He could not be a silent spectator and, in fact, deeply meditated on these problems from a geologist's point of view.

As a measure against floods in the major north Indian rivers Dr Rajnath suggested a Trans-Deccan Canal, a waterway joining the Bay of Bengal with Gulf of Kutch. This, he felt, would not only serve as an exit for the waters of rivers in spate at suitable places but also be advantageous in several other respects, such as cheaper transport and navigation, etc. Such seaways with big inland encroachment do exist in other countries. Moreover, its cost would be negligible compared with the periodic losses of crop, property and life, both human and animal. Among other remedial measures for floods, suggested by him, are : (*i*) construction of a network of small reservoirs to serve for greater percolation of water underground and for arresting additional discharge; and (*ii*) proper planning and management of our forest resources, the process of deforestation and aforestation.

To face drought, he stressed upon following the age-old maxim of hydrology : *"water lost should be water gained."* Dr Rajnath, therefore, suggested extensive "water spreading" over the areas where undergound water was heavily tapped.

In preference to canals dependent on water of the rivers, he recommended construction of tubewells on a large scale through which the subsurface water at shallow depths as well as in deep aquifer zones could be tapped to meet increasing demand for irrigation. This, he felt, should be done after proper geological investigations in regard to capacity and extent of productive aquifers, and the nature of overlying strata. The spacing of tubewells should be well planned *vis-à-vis* the sites of productive agricultural fields, power, etc. Alternatively, for the areas not having rich resources of underground water or those not far from the source of supply, he suggested a combination of the two methods, i.e., "a canal dependent on water either pumped from such areas where the underground resources of water are in plenty or pumped from... a river with a water level much below that ground level."

During a survey of the erstwhile Bilaspur state (presently, in Himachal Pradesh), Dr Rajnath discovered white sandstone of Krol Formation to be "a useful material for the manufacture of glass." Moreover, the galena associated with that parent rock was found to contain "about one ounce" of silver in one "long ton of the ore." Further, he worked out for the first time the geology of the occurrence of

"Shilajit," a well-known ayurvedic tonic drug which has been in use in India from times immemorial, in Krol Limestone, Nahan Sandstone and Recent Conglomerate.

The paper on the "Iron pyrites deposits near Simla" created a stir among the officers of the Geological Survey of India at the 28th Indian Science Congress held at Varanasi since he had estimated (in that paper) the possibility of "large reserves" of ore. This enabled the entrepreneurs to manufacture sulphuric acid in India at a time when import of sulphur from foreign countries was cut off.

Professor Rajnath felt that Indian *Jari* industry could capture the international market by cheaper manufacture. This was possible only if ruby-dies were available at low cost. To achieve this objective, he suggested manufacture of synthetic rubies as the country had the raw materials for the purpose. Also, over a decade ago he envisaged the necessity of starting a factory for the manufacture of artificial gems which play a significant role in a large number of civil and defence industries.

A Teacher

Dr Rajnath's potentialities for being a teacher had been appreciated by his seniors right at the beginning of his career. His being summoned back to Varanasi from London by Professor Mathur, when the latter was to go abroad on long leave for his treatment, was itself a testimony to the fact. Professor W. W. Watts, F.R.S., said : ".... (*he*) *has not only great and unusual ability for original research work but has also the knowledge, talent and resources of an excellent teacher.*"

Dr Rajnath was a man of high principles and he adhered to them steadfastly. The author had the opportunity of appreciating them during the first two years of his entrance into the teaching profession and even more so when he assisted him in the teaching assignment at the University of Roorkee in the summer vacation of 1951. Professor Rajnath impressed on his young colleagues the foremost imperative : thorough preparation of the topic of a lecture in advance. While arranging the subject matter, his advice was, one should bear in mind the mental level of the students concerned. In addition, the expression should be so lucid that the audience may grasp and retain it felicitously. Besides, the emphasis should first be on the elements, followed in the natural course by greater details. The simplicity of these injunctions as well as their effectiveness was of great significance. Surely, the success of a teacher depends on them.

Geological pursuits are both academic and practical. One studies, on the one hand, the origin of the earth as well as the structure of its interior, work of natural agents such as lakes, rivers, sea, etc. in the open terrain, the causes of earthquakes, the volcanism, and so on. One cannot afford to ignore, on the other hand, the useful (economic) deposits associated with sediments or caused by volcanic activity, and also the protective/precautionary measures against devastation by quakes. Mere discovery of new groups of microfossils is not exclusively the open sesamé to locating stratigraphical traps for oil. Their time-range, distribution and ecological features are also to be studied. For service of mankind, the mutual suspicion between the advocates of "academic" and "commercial" frontiers should

give way to understanding and co-operation. The formei must increase their utilitarian (applied) activities whereas the latter must become more willing to acknowledge value and validities of ideas originating in cloistered halls. Accordingly, Professor Rajnath disregarded any distinction between the pure and the applied in the study of Geology. He maintained that Geology as a whole, besides being a natural science, was an applied science.

He believed in an overall grounding (of students) in the subject. Likewise, he desired his young colleagues to be associated with major sub-disciplines of Geology. He, too, whenever needed, taught branches other than Palaeontology and Stratigraphy. The present author had the opportunity of seeing Dr Rajnath's detailed notes on subjects such as Economic Geology including mineral prospecting, and Engineering Geology. He was thus a broad-based Geology teacher. His aforesaid principle of training, particularly at the post-graduate level, is even today of great advantage to young aspirants for wider job opportunities. While suggesting the area for the present author's thesis as part fulfilment of his M.Sc. examination, the Professor took care that it contained a variety of rock types and even a few economic minerals.

Professor Rajnath always felt that if in the teaching institutions we could produce really educated, resourceful and imaginative geologists, they would take care of the applications themselves. If we can only teach our students to use their brains, it is certain that they will apply them in whichever profession they may enter. With this goal in view, and in keeping with the ideals and traditions established by his *guru,* Professor Rajnath consolidated and intensified teaching and research in major branches of Geology. In addition, he laid emphasis on the applied aspects. This led to the introduction of courses in Engineering Geology, Hydrogeology, Ore-dressing, Geochemistry, Micropalaeontology and Sedimentology at the post-graduate level in Banaras Hindu University; provision of teaching Elements of Mining and Surveying was already there. As usual, there was emphasis on field training in the curriculum of studies at all levels. Besides, instead of special paper(s) he preferred a dissertation (thesis) as part fulfilment of M.Sc examination so that the students were initiated into undertaking independent field and laboratory investigations, and thus could learn the art of "intelligent compilation" and presentation of data.

As a teacher, Professor Rajnath was a careful organiser of the minds which he helped to mould. He was very conscientious, dutiful and hard-working, qualities which he always tried to inculcate in his pupils and colleagues. Heavy and pressing demands on his time because of other official duties never led him to any short-cuts in teaching. Rather, he overworked himself to complete the prescribed course. He practically never enjoyed a vacation. He wanted strict observance of rules and discipline, but was also sympathetic, generous and considerate, almost to a fault, to his students. No wonder he was held in high esteem by his students and colleagues. Many a time he quietly helped students financially (by giving loans or gifts) in the hour of their need, without letting anybody know about it.

Professor Rajnath was singularly free from petty provincialism and parochialism. He felt upset and worried at parochial, regional and caste tendencies which occasionally surfaced in academic institutions like the Banaras Hindu University.

On the other hand, he encouraged and supported regional associations for developing a cosmopolitan culture through cultural exchanges and at the same time, advised students to develop an all-India character and spirit.

Professor Rajnath's role in the spread of geological education and industrial development of the country has been significant. Many of his pupils have successfully held and still occupy key positions in various teaching institutions, government organizations and other establishments, *viz.*, Geological Survey of India, Atomic Energy Commission, Oil and Natural Gas Commission, Indian Bureau of Mines, Central Ground Water Board, Mineral Exploration Corporation, Wadia Institute of Himalayan Geology, etc. He himself served on a number of academic bodies of various institutions and helped them in planning, growth and development of their Geology Departments and in framing curriculum of studies.

An Administrator

Professor Rajnath was an Argus-eyed administrator with a cool head and balanced judgement. He was modest and gentle, and so polite that his students and junior colleagues always received a warm welcome from him. Because of his sympathetic nature he could never be harsh. Often, one got the impression that he was reluctant to punish but it was his nature to be kind and compassionate. His intentions were never unfair even though it may not have been possible for him to please all. Two of his pupils, whom he loved much and are presently occupying high positions in two different Universities, could not be recommended for appointment in the Banaras Hindu University in the first instance. Naturally, they felt disappointed and even shocked. But it can be stated here on personal knowledge that both of them could not get in because of the principles on which the selection was made.

Official duties at Varanasi had top priority with Dr Rajnath : " *I have always thought it my first duty to be at the disposal of University work by devoting maximum possible part of my time to it.*" He maintained secrecy in official business and never leaked out any confidential matter, not even by dropping hints. He emphasised an "all-round development of Geology" in the Department, encouraging his colleagues to specialize in different subdisciplines and new areas. He was never partial to his own branch. In his planning he always had in his mind the future interest of the budding members of the Department.

Love of Service and Spread of Education

The Departments of Glass (presently, in Ceramic Engineering), Geography, and Geophysics in the Banaras Hindu University owe their setting up and development to his ardent efforts. This again was done for the love of science and spread of education. These departments, initially part of the Department of Geology, became independent in 1939, 1946 and 1964 respectively. They have since attained their proud place among about a hundred departments of the Banaras Hindu University.

Dr Rajnath had the privilege of working under a galaxy of illustrious Vice-Chancellors of Banaras Hindu University such as the founder of the University himself, Mahamana Malaviyaji, Dr Sir S. Radhakrishnan (later President of India and Visitor of the University), Acharya Narendra Dev, Dr Sir C. P. Ramaswamy Iyer, etc. All of them appreciated unequivocally his simplicity, sincerity of purpose, devotion to duty and loyalty to the Institution. Professor Rajnath always had the larger interest of the University in his mind.

He served on the various bodies of the University, including the Executive Council, as an elected or *ex-officio* member. Whenever called for he expressed his views independently. He, however, avoided entering into controversies. Admittedly, he did not participate much in discussions at the meetings but followed the deliberations carefully. He was in the habit of studying the agenda and relevant papers well before the meetings. His timely interventions have occasionally turned the tables and set right unwise steps.

A Humanist

Dr Rajnath maintained that an individual is influenced by many people and bears the imprint of various personalities; but he builds his own character in the footsteps of his illustrious forbears. The first and foremost to influence and help him build his own character was his father. Though Rajnath lost him when he was quite young, his father's sincerity, honesty and modesty left a deep impression on the son, whoever remained conscious of his ideal that the blessings of poverty were far greater than the heady pleasures of ill-gotten wealth. Inspired by him and by his preceptors in the University, Professor Rajnath observed austerity, imbibed the spirit of public service, developed a high moral character, love for students and wide human sympathies for the poor and needy. His personal needs were few. He always preferred indigenous products. He avoided luxuries. Once one of his near relatives (in-laws) was eager to present him a car but he politely declined the offer. In this context, he very often used to say : *it is easy to own an elephant but difficult to feed it.*

During the summer vacations, while a University student, he organized volunteer corps to serve drinking water to thirsty travellers at Nagina (Paternal home town) railway station. This act was widely appreciated by the public, particularly because of inadequate arrangements for the supply of drinking water at the station in those days, though it was criticised as seditious and a slur on the prestige of the family by one of his cousins (a Rai Bahadur). Dr Rajnath used to donate liberally for a cause that appealed to him.

To sum up, Professor Rajnath was a pious and noble soul; a man of principles with progressive views, and he scrupulously followed the motto of plain living and high thinking. He was free from all forms of egotism. His modesty, politeness and gentlemanliness were exemplary. He was a thorough nationalist, and yearned for an organized effort towards rural reconstruction, particularly to meet the basic needs of the villagers.

Honours

In recognition of his scientific contributions, Dr Rajnath was elected, at a relatively young age, President of Geology Section of the Indian Science Congress. He delivered his scholarly address on "The Jurassic Rocks of Cutch—Their bearing on some problems of Indian Geology," at the 29th Session held at Baroda in January, 1942. He was elected Fellow of the National Institute of Sciences of India (presently, Indian National Science Academy) in 1943.

In 1949, he went to Nepal as a Member of the Goodwill and Scientific Mission led by Professor Satyen Bose, an eminent Indian physicist. Professor Rajnath was Founder Vice-President of Palaeontological Society of India, and Fellow/ Member of several other learned bodies such as Mining, Geological and Metallurgical Institute of India and National Academy of Sciences of India, etc. Furthermore, he was associated with the Editorial Board of the *Journal of Ayurveda,* New Delhi.

Family

Dr Rajnath was married to Daya Rani, who was not unfortunately destined to live and give him her company for more than two years. She left behind her an infant daughter, Indu by name. Later, in 1937, Dr Rajnath married Chandrakala Devi, who bore him a daughter, Manju, and two sons—Pratap Mohan and Chandra Mohan. The elder son is with Messrs General Electric, Louiseville (Kentucky, U.S.). The elder daughter is married to Shri Yogendra Pal Singh Bishnoi, Deputy Chief Engineer (Design), Bokaro Steel Plant, and the second one to Shri Krishna Singh, currently Commissioner Income-Tax (Admn.), New Delhi.

Last Days

Dr Rajnath was slenderly built in his youth. He gained obesity with age, which was, however, misleading. He excelled many a young man in stamina and endurance. He had all along been putting in very long hours of strenuous work. As he was habituated to a busy routine, his health was rendered weak after retirement. During the last two and a half months of his life Professor Rajnath did not keep good health. He suffered from pneumonia, pleurisy, etc., and passed away around 09.30 hours on Sunday, August 6, 1972.

He is survived by his wife, two daughters and two sons.

S. K. Agrawal

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REBALA VENKATA SESHAIYA

(1898–1973)

Elected F. N. I. 1961

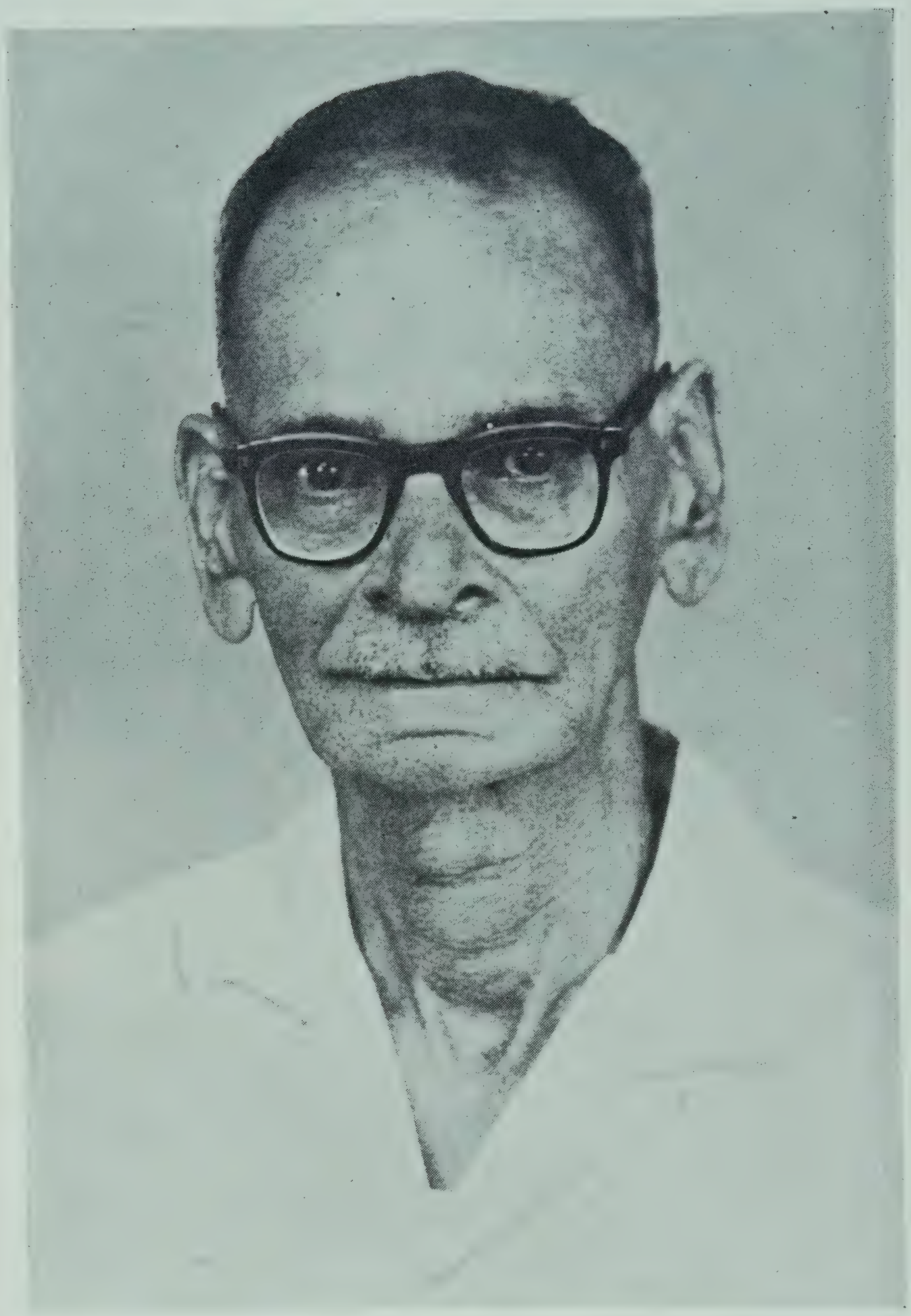
REBALA VENKATA SESHAIYA was born on February 8, 1898 as the only son in a middle class family at Nellore, Andhra Pradesh. After his schooling in the American Mission School at Nellore, he joined the Madras Christian College in 1913 and secured a first class-first rank in B.Sc. (Hons.) Zoology examination in 1919 and won a microscope (on his preference) as *'Caithness Prize'* which actually gave him the added impetus for research. After working as Demonstrator and Lecturer in Zoology for two years, he served as Headmaster of the Mahanth High School, Tirupati (Andhra Pradesh) for ten years, during which period he established there an excellent museum of local fauna and flora. Even today this stands in testimony to his love, enthusiasm, and deep dedication for the subject and for its teaching.

RESEARCH CAREER

The name of Professor R. V. Seshaiya will continue to occupy a prominent place in the history of zoology in India. His researches on molluscs are classic in invertebrate embryology and helped lay the strong foundation on which the molluscan embryology in this country stands very high. With his ability and perseverance, coupled with his insight and broad vision, he embarked on an active research programme and continued it for fifty years, bringing forth a steady flow of articles and reviews in addition to many theses.

A GREAT TEACHER

Professor Seshaiya was a born teacher who broke all the rules and yet he was profoundly successful. He was a man of extraordinary parts and could do well in anything he undertook, as a student, as a teacher and as a researcher. He was ever a good and successful teacher and it was that which counted. Apart from his scholarly writing, much of what we know of the teaching genius of him was the spoken testimony of many of his students, colleagues and admirers. He was known by the mark he had left on his students. It was certainly not a mark of indoctrination because he had two particular attributes, namely the ability to awaken and to stimulate delight in the use of the mind together with a belief (almost a religious faith) in its value to the students. He was admired most because he engendered in his students a pleasure, a joy, a raised awareness in intellectual



R. V. Veshanjo

activity. Most of his students discovered pleasure in following his ideas, satisfaction in discovering where they led to though this did not come always easily to one and all. The maturity and intellect of this teacher got translated to some of his students so that they went beyond the years. Professor Seshaiya not only believed in this but actually practised it admirably. It always manifested in his words and deeds.

As a researcher, he was an interpreter in the house of learning in the sense he was able to put a student in connection with a problem and lead him to seek, prove and press an engagement with it on his own. In his role as interpreter, his own heart and convictions came through subtly and quietly. As a teacher, with a broad vision and an open mind for facts, he believed that rote learning today is worth even less. To him, teaching and research were like two poles of the magnet since neither had much force without the other. According to him, the link between good scholarship and good teaching should always remain very strong and a balance must be kept to preserve the dignity of the teacher-scholar as a teacher, not solely as a scholar.

He advocated to his students, to his colleagues and to all the educators that meaningful and personalised contacts between the teacher and the taught be maintained in order that the teachers, who are interpreters to the coming generations, will leave their mark on them : the mark of maturity, of the use of mind, of thoughtful conviction.

All those who came under his influence found in him a wise guide and a strict disciplinarian with an eye for precision and perfection. His capacity to spot the latent potential in a student and to inspire him with an infective enthusiasm was unrivalled.

Book Lover

Professor Seshaiya remained a bachelor and the only love in his life was the love for knowledge. His whole life was dedicated to work and learning. His love for books was legendary and his personal collection contained thousands of volumes practically on every subject on earth. His profound learning was such that he could talk with authority on English literature as he would on embryology of molluscs.

At the Annamalai University

Professor Seshaiya has left an indelible mark on the Departments of Zoology and Marine Biology of Annamalai University where he served as Head in succession for nearly four decades. With dedication, he took active and personal interest in all his students and helped them in every way and many were his unknown acts of kindness and generosity. With his characteristic ability and thoroughness, he gave his undivided attention to the proper and full development of the Department of Zoology first and to the Centre of Advanced Study in Marine Biology later and thus has left behind him a tradition of excellence, scholarship and industry. He persistently refused to accept various positions and jobs offered to him, time and again, and remained loyally wedded to the Departments of Zoology and Marine

Biology of Annamalai University till the end. He lived a very simple, austere life and his wants were always very few. He was a good conversationalist and a ready wit. He did his work all the time with humility without expecting any rewards and he trained his students to take up a similar attitude.

Honours

In a befitting manner and in recognition of his valuable contributions he was elected President of Zoological Society of India and of the Zoology Section of the Indian Science Congress in 1964–65. He was also invited to many Universities in India for special lectures.

The name of the late Professor Seshaiya will always be remembered as a dedicated Zoologist who pursued his work with acknowledged success, ceaseless devotion, singleness of purpose, and as the founder father of the Centre of Advanced Study in Marine Biology of Annamalai University at Parangipettai. He retired in June 1970, after a record period of continuous service of forty years in Annamalai University and died on February 21, 1973 after a very brief illness. He has left behind a handful of his students to carry on his tradition of excellence with devotion, dedication and humility.

R. Natarajan

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SUDDHODAN GHOSH

(1896–1976)

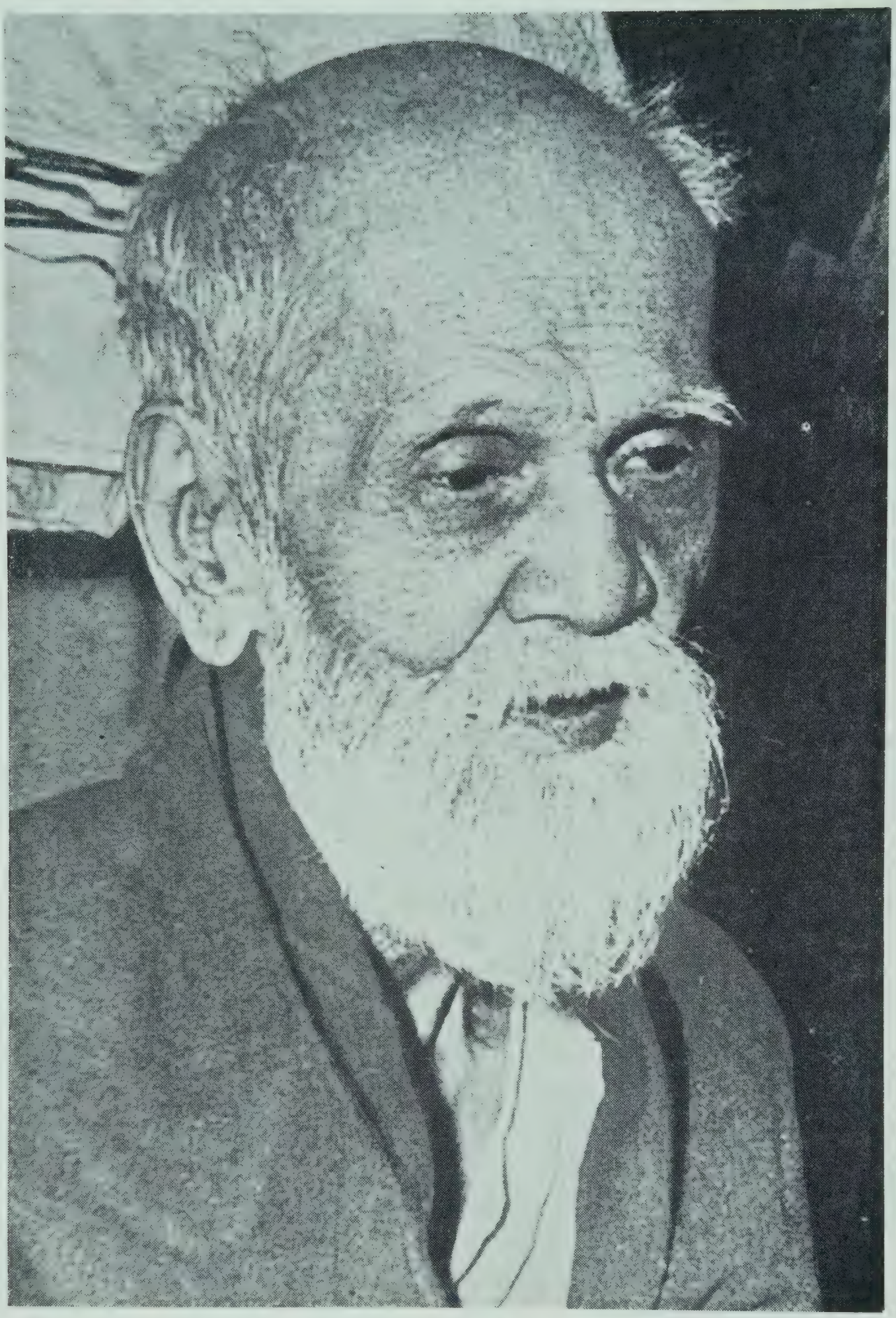
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Birth, Parentage and Childhood

Suddhodan Ghosh was born in Calcutta on July 26, 1896, with a silver spoon in his mouth. He belonged to an aristocratic Kayastha family of Bengal. In days of yore, his ancestors lived in Gobindapur, in the vicinity of Fort William. With the advent of the British, the family shifted to Behala and thence to Jorasanko, near the palace of the Tagore family. They built a castle there. When baby Suddhodan first opened his eyes, he saw a world of sunshine and splendour. His father, Sarat Chandra Ghosh was an affluent landlord, while his mother Patitpabani Debi, was a generous and devout lady. They had twelve children—five sons and seven daughters. Suddhodan was the fourth son and eleventh child.

Ghosh's grandfather, Harachandra Ghosh, was a prominent personality. A contemporary of the eminent littérateur, Bankim Chandra Chatterjee, he was in the first batch of students to graduate in Arts from the Calcutta University. He was also the first Bengali Chief Judge of the Calcutta Small Cases Court, where his marble bust still adorns its courtyard. Harachandra's eldest son, Pratap Chandra Ghosh, assumed reins of the family. A strict disciplinarian, he was also an orthodox puritan. He exerted a firm but benign influence over the family. Young Suddhodan was deeply attached to his uncle for his truth, application and rectitude of conduct.

When asked about his early life, a montage of childhood memories flashed through his mind. He narrated : "I was born a weakling. My delicate constitution did not permit me to participate in any healthy pastime. I could hardly run a few yards for want of breath. The house physician prophesied that I would not outlive a dozen years. Thus, I became my mother's pet and pampered child. Nobody scolded me. Thanks to my mother's prayers and penance and through God's grace, I outwitted the doctors and developed into a normal child. Books became my delight, my one absorbing passion. With a passion for books, I developed a love of solitude. Alone and aloof from the excitements of the world, I delved into books and scriptures, watching things profane and things divine from a distance."



S. Ghosh

Formative Influence during Early Life

The Ghosh family was large. Their residential palace accommodated more than a hundred inmates. It included the joint families of Pratap Chandra Ghosh and his two brothers, their progenies, retinues and guests. The days were crowded with ceremonies, religious festivities, feeding destitutes and giving alms to the needy. Thus, as a boy, young Suddhodan secured first-hand experience of the joy associated with perpetual giving and expecting nothing in return.

He also regularly attended the learned discourses of Sanskrit Pandits and renowned scholars, who congregated at his home. Buddhist pilgrims from Tibet and the far east were spontaneous visitors. The essence of Buddhism and Jainism found a responsive echo in his heart. Mahamahopadhyay Chandrakanta Tarkalankar was a neighbour and family friend. He related mythological stories from the Ramayana and Mahabharata to the children. The legend of Bhishma and his sacrifices set young Suddhodan's heart aflame. He took a vow to follow his footsteps, and verily, he did succeed. The blow of circumstances shaped his character from the rock while his soul acquired lustre and purity in the refiner's fire.

In his youth, Suddhodan Ghosh witnessed the emergence of the golden era of Bengal. The leaders were Vivekananda, Aurobindo, Rabindranath Tagore, Surendranath Banerjee, Chittaranjan Das and others. They dreamt about the glorious future of the Motherland. Suddhodan Ghosh was drawn into these visionaries' vortex. In his early youth, he adored Tagore. He attended every single meeting addressed by him. He often recited the following lines from "*Gitanjali*".

"Where the mind is without fear
And the head is held high;
Where knowledge is free;
Where the world has not been broken up
Into fragments by narrow domestic walls;
Where words come out from the depth of Truth
Where tireless striving stretches its arms towards perfection;
Where the clear stream of reason has not lost its way into the dreary sand of dead habit;
Where the mind is led forward by Thee into ever-widening thought and action—
Into that heaven of freedom,
My Father, let my country awake."

During later years, Mahatma Gandhi cast a spell over him. He joined the Non-Cooperation movement. He courted imprisonment in 1921, and spent three months in jail for participating in the struggle for national independence. He lived a simple, austere and dedicated life. He wore only Khadi clothes and garments, made from self-spun cotton fibres. Charkha spinning was his daily ritual. He established close association with self-supporting organisations like Abhoy Ashram, Khadi Pratisthan etc. However, the internal strife within the Congress Party distressed him. With Gandhiji's permission, he left the Congress Party. He

ceased to be a politician, but remained a true nationalist to his last breath. Ironically enough, Gandhiji, himself, ceased to be a member of the Congress Party years later.

Acharya P. C. Ray was his distant uncle. He was a bachelor and lived a life of self-denial. The same simplicity and naturalness also characterised the dress and manners of Suddhodan Ghosh. He also reduced his diet to the minimum, necessary for the preservation of life. He could not but strike a casual visitor with awe and reverence due to his christ-like appearance and saintly character.

School and University Education; Preliminary Research

Suddhodan Ghosh took to reading, writing and Arithmetic during his infancy, just as a duckling takes to water. He became a child prodigy. Mathematics was his forte.

He took his admission in Vidyasagar's Metropolitan Institution as a student of the eighth (present day third) class. Soon he outshone all his rivals. In quest of keener competition, he sought admission into the Hindu School with its hoary tradition. His grandfather Harachandra Ghosh happened to be one of the founder-donors of the Hindu school. But young Suddhodan refused to seek admission as a donor's candidate. He was admitted to the fourth (present day seventh) class in 1910 strictly on merit. He topped the list of successful candidates. He became a favourite of the renowned mathematics teacher Upendra Lal Bakshi. Often he was called upon by his teacher to go to the blackboard in the next higher class and solve difficult problems which his seniors could not tackle. Sri Dilip Kumar Roy, the renowned singer, was one year senior to Ghosh.

In 1914, Suddhodan Ghosh passed the Matriculation examination in the first division, getting a place near the tenth position in order of merit.

Soon an atmosphere of gloom descended over the Ghosh family. The head of the family, Pratap Chandra Ghosh, expired. His youngest brother embraced Christianity. The joint family disintegrated. There was a touch of sadness in everything. During this period, Suddhodan Ghosh joined the Intermediate-in-Science class of the Scottish Church College. In the annual examination for promotion into the second year class, he topped the list of successful candidates. He became eligible for a scholarship, but there was a precondition attached to the award. The scholar had to sign a declaration that he came from a poor family. Suddhodan hesitated to sign the form, because he could not acknowledge that his father was indigent. The rector was agreeably surprised by the boy's forthrightness. He gave him a day to reconsider his decision, but Suddhodan remained adamant. Next day, he reiterated his earlier decision. Consequently, the second boy got the scholarship. In the joint Intermediate final examination (I. A. & I. Sc. together) of the Calcutta University in 1916, he secured the eighth place in the merit list. Incidentally, he got the highest marks in Mathematics.

He joined the third-year B.Sc. class (with Honours in Mathematics) of the Presidency College, Calcutta. During this period he had to face financial difficulties. One of his aunts, who had been married into a rich family, came to his rescue. She gave him enough money to purchase his books and a wooden

almirah to store them. This almirah remained in his possession till the last. Now it has been preserved in the Bangiya Bijnan Parishad with the relics of Dr Ghosh. It is needless to add that his aunt's loan was promptly repaid after he got the scholarship.

With his joining the Presidency College, began the golden era of his academic career. He came under the tutelage of eminent teachers like Acharya J. C. Bose, Acharya P. C. Ray and Dr D. N. Mallik and blossomed into a top-ranking scholar. He stood first with first class in the B.Sc. (with Mathematics Honours) examination of the Calcutta University in 1918. He was awarded the University Gold Medal for his brilliant performance. He took the medal home and placed it at the feet of his mother, who was visibly moved. She reciprocated his gesture by presenting him with a gold mohur (Akbari era), which she had earned from Pratap Chandra Ghosh as a reward for her exquisite floor decorations. Dr Ghosh cherished this mohur as his greatest treasure. After his demise, it was gifted to the Calcutta University museum, in deference to his last wish.

He joined the University College of Science and Technology at 92, Upper Circular Road, Calcutta in 1918 as a post-graduate student of Mixed Mathematics. He studied Mathematical Theory of Elasticity with Professor S. N. Bose, who was then lecturer in the department. He passed the M.Sc. examination in 1920 standing first in first class, securing about 90 per cent marks, earning the University Gold Medal. Unfortunately, his mother did not live to witness the presentation of the second award, she had expired a year earlier.

Next, he worked as a research scholar under the guidance of Professor Nikhil Ranjan Sen, then Sir Rash Behari Ghosh Professor of Applied Mathematics.

Professional Career

After obtaining the topmost rank in the M.Sc. examination in Mixed Mathematics in 1920, Suddhodan Ghosh was offered a prized post at the Imperial Bank of India. Unhesitatingly, he declined the offer, since he did not wish to abandon mathematics. Sometime later, Sir P. C. Ray offered to obtain for him a scholarship for advanced study abroad. This too, he declined. He did not like to leave his Motherland. He felt that while poverty and struggle for existenee sometimes dampened intellectual ardour, wealth and affluence invariably did so. The most suitable condition for a scholarly life according to him, was one above want—not exactly affluence, but immunity from petty worries of life, security against the uncertainty of the morrow. And so, he became Sir Rash Behari Ghosh Research Scholar with a pittance of Rs. 75/- per month. In 1925, he competed for and won the Premchand Roychand Studentship Prize of the Calcutta University—the most coveted award at the disposal of the University. He also won the prestigious Sir Asutosh Mookerjee Gold Medal of the Calcutta University for his outstanding researches in Mathematics.

After obtaining the D.Sc. degree of the Calcutta University in 1928, he was persuaded by Professor S. N. Bose to join the Dacca University as Lecturer in Mathematics. But, after a brief stay at Dacca, he returned to his *alma mater* and

joined the Department of Mixed Mathematics. Soon he was acclaimed as a great teacher and top academician by his pupils and colleagues.

In 1953, the Calcutta University selected Dr Suddhodan Ghosh as the first Reader in the Department of Applied Mathematics. He, however, declined to accept the appointment, since he felt he was superseding a senior colleague. The university authorities were non-plussed; however, they averted the complication by transferring the Readership to a sister department.

A somehwat similar situation arose in 1954, when Sir J. C. Ghosh was the Director of the Indian Institute of Technology at Kharagpur. The vacancy for the post of a Professor and Head of the Department of Mathematics at the I.I.T. was advertised. A contemporary of Dr Ghosh (Dr B. Sen) approached him and said : *"I wish to be an applicant for the post. But, if you happen to be a candidate, I don't have any chance whatsoever."* Smilingly, Dr S. Ghosh assured his colleague that he would not stand in his way. He said, *"I was at first inclined to apply for the post, because I felt that this opportunity was a gateway towards the fulfilment of a long-cherished dream to establish a centre for advanced studies in Mathematics in our country. But, on second thoughts, I felt that the administrative burden associated with the post of Head of Department may not prove conducive towards the attainment of my goal. Furthermore, the age for retirement at the I.I.T. is rather too short for a man of my age."*

Somehow, this matter reached the ears of Sir J. C. Ghosh, to whom the name of Dr S. Ghosh had been strongly recommended by Professor S. N. Bose He requested Dr Ghosh through Professor N. R. Sen, to apply for the post. He also assured him that there would be provision for an assistant to lighten his administrative load and there was every likelihood of his services being extended beyond the prescribed retirement period. Dr Ghosh pondered over the matter for a while and then sent his reply expressing his inability to apply because he had previously given his word to a friend that he would not be a candidate. He was then informed that the authorities did not consider his friend to be the most suitable candidate and again requested him to apply. But the votary of truth could not be dislodged from his self-chosen path of righteousness. Eventually, the post went to Professor B. R. Seth.

Life is a series of disenchantments, and Dr Ghosh had to have his share of them. In 1958, he had a minor difference of opinion with the Head of his Department regarding the curriculum and distribution of teaching load among the members of the staff. As a result, he sent his letter of resignation. Fortunately, the university authorities ignored his letter because he was regarded indispensable to the Department of Mathematics. Subsequently, Dr Satish Chandra Ghosh, treasurer, Calcutta University, and a well-wisher persuaded him to join the Department of Pure Mathematics and soon he was elevated to the post of the Head of the Department.

After the retirement of Professor N. R. Sen in 1959, the post of Sir Rash Behari Ghosh Professor in the Department of Applied Mathematics fell vacant. It was offered to Dr Suddhodan Ghosh, although he was not a candidate for the same. He accepted the post with his customary humility. Thus, Dr Ghosh had the

unique distinction of becoming the Head of the Departments, of both Pure and Applied Mathematics, a rare and unique privilege.

Professor Suddhodan Ghosh retired from active service in the Calcutta University in 1963. His students, friends and admirers tried to persuade him to apply for the post of Scientist—Emeritus, subsidised by the University Grants Commission. But he stuck to his idealism of 'Non-seeking of any favour from any source', and turned a deaf ear to their requests.

Role of a Teacher

Dr Suddhodan Ghosh was a born scholar and teacher. Early in his life, he vowed to dedicate his life to the pursuit and dissemination of knowledge. He kept this resolution to the last. During his post-graduate years, he occupied a single room in the outhouse of the family residence. It was his study-cum-bedroom. 'Early to bed and early to rise' was his motto. He would get up at 4 a.m., finish his morning ablutions, prepare a cup of coffee and sit among books. The family barber attended the household twice a week. His clients were many. And so, in order to save time for study, he preferred to sport long hair and a beard. They remained his hall-mark throughout life.

Clad in immaculate khadi, tall and handsome in appearance, with a flowing beard, he looked like an Aryan sage and captivated the hearts of his students. As a teacher, the methods adopted by him were often novel. Every year, he used to pick up new materials from different books and incorporate them in his lectures. He used to change his topics every two/three years for the benefit of his students and to keep himself up-to-date in every field of the teaching curriculum. Before taking up a new topic, he used to collect all available books on the subject from the university library and the local bookshops and study them thoroughly. Then he would scrutinise every aspect of the subject in detail, simplify the difficult points, work out the suggested problems and prepare extensive personal notes. He used to deliver his lectures extempore from his own notes, making his exposition easy and lucid for his students. What he taught was not really separable from his personality. The material which he offered was not objective stuff; it was material composed not only out of his mind and intellect but with his will and character. The students were spellbound and listened to his lectures with rapt attention. He did not resent recalling the salient points if any student failed to grasp the idea. He had to spend more lecture hours than usual for the benefit of his students. Before the university examinations, he helped the students by taking extra coaching classes on any topic suggested by them. As a matter of fact, he really enjoyed teaching even as an artist enjoys painting, a musician enjoys music or a sprinter enjoys competition on the racing track. Apparently brief and terse in his conversation with his students, he entertained a warm feeling of love and affection for them. The silent flow of his affection could be felt by all and remembered with deep gratitude.

As a research guide, he had hardly an equal. Assuming the role of an ideal *Guru*, he would teach quietly the relevant topics, day after day. He would help focus attention of his research associates on the essential points, generate a sense of

self-confidence in them and prepare them to tackle original problems. He looked into the future and kindled their creative faculties.

His punctuality and regularity were proverbial. During his long career of thirty-five years as a teacher in the Calcutta University, it is believed he availed himself of casual leave for only thirteen days. He never took any privilege leave.

Research Activities and Contributions to New Knowledge

An ardent student of the late Professor S. N. Bose, Suddhodan Ghosh was irresistibly drawn towards Mathematical Theory of Elasticity. He developed a research interest in the subject even as a student of the Post-graduate class and published his first paper before joining the Department of Mixed Mathematics as Ghosh Research Scholar.

Subsequently, as lecturer in the same department, he worked mostly alone. There was hardly any provision for a salaried research scholar, associated with a lecturer at the Calcutta University. As his research activities widened, encompassing fields of both Applied and Pure Mathematics, many research associates, mostly honorary, congregated around him. He guided them in their doctoral theses. However, he never wrote a paper jontly with any student working under him for a doctoral degree. This was indeed a rare quality.

Ghosh's work comprises essentially two fields : Fluid Dynamics and Problems of Elasticity. The latter includes bending of plates, plane strain, plane stress, generalised plane stress problems in isotropic and aeolotropic bodies, vibration of ring, and torsion-flexure problems. An analytical survey of his scientific contribution is enumerated below :

Fluid Dynamics

Liquid motion inside certain rotating circular arcs, with specified boundaries was discussed by Ghosh (1924), by solving Laplace's equation in Ψ, the stream function and its value on the boundary.

The problem, 'On the steady motion of a viscous liquid due to translational velocity of a tore parallel to its axis', was solved by him (1927) by using curvilinear coordinates (α, β) and by assuming the Stoke's function $\Psi=(\mu-\cos\beta)^{-3/2}\chi$, where χ denotes an infinite series of $\cos n\beta$ and $\alpha + 2\beta = \log\{(\rho + \alpha + iz)/(\rho - \alpha + iz)\}$, (z, ρ) being cylindrical co-ordinates, the boundary conditions of Ψ having been expressed as $\Psi + \frac{1}{2}\rho^2 v = 0$ and $\frac{\partial}{\partial n}(\Psi + \frac{1}{2}\rho^2 v) = 0$.

Later, he persuaded Srimati Lakshmi Sanyal, a pupil and research associate, to examine critically the foundations of the three dimensional boundary layer theory on a surface. The asymptotic equations of the boundary layers were deduced in the same manner as that by Schmidt and Schröder (1942) in their determination of the equations of the two dimensional boundary layer theory. But Sanyal's (1957) equation contains a correction term which does not appear in Howarth's (1951) equation, and it has a form more precise than that of Howarth. With the

help of Tensor Calculus, Sanyal also obtained boundary layer equations analogous to those of Lin and included a correction term, which was lacking in Lin's equation. Under the guidance of Ghosh, Sanyal published the following papers :—

(i) On similarity solution of Prandtl's boundary layer equation (1955*a*).
(ii) Two dimensional boundary layer flow along a wall in a converging channel with curved boundaries (1955*b*).
(iii) Boundary layer in a converging nozzle with a spherical surface (1955*c*).
(iv) The flow of viscous liquid in a circular tube under pressure gradients varying exponentially with time (1956*a*).
(v) On the flow of a viscous liquid between two co-axial circular cylinders under a periodic pressure gradient (1956*b*).
(vi) Equations of motion of an incompressible viscous fluid in parallel system of co-ordinates (1957*a*).
(vii) Three dimensional boundary layer equations. (1957*b*).
(viii) Jet issuing in all directions from a thin slit round a semicircular cylinder of small radius containing liquid under pressure (1957*c*).

Elasticity

(a) *Bending of Elastic Plates*—In 1829, Poisson had solved the problem of bending of a loaded circular plate, where the load is uniformly distributed. Later, Saint Venant considered the case of the load being uniformly distributed round a concentric circle, while Michell (1902) took up the problem of a concentrated load at any point.

Ghosh (1925*a*) obtained the form of the deflection of a plate, when (i) the load is uniformly distributed between two concentric circles and two radii and (ii) the load is uniformly distributed along the arc of a concentric circle.

The solution of $\nabla_1^4 \omega =$ constant, was obtained by him (1925*b*) in bipolar coordinates and employed to find the deflection of an elastic plate bounded by two non-concentric circles and bent by its own weight.

Happel (1921) gave the solution of bending of an elliptic plate loaded at the centre. Ghosh (1929) obtained the solution of a similar elliptic plate when the load is concentrated at the focus.

(b) *Problems of Dislocation*—This arises in a body occupying a multi-connected space when it is cut along a system of barriers put in to make the body simply-connected, the opposite faces being then joined by the removal or insertion of thin slices of matter of the same kind as that of the body. The new body so formed would then be in a state of initial stress. There is thus the physical possibility of the displacements in multi-connected space being expressed by many valued functions. Volterra (1907) had applied the solution of equations of equilibrium in polar co-ordinates to the problem of dislocation in a hollow cylinder bounded by two concentric circles. Ghosh (1926) used the expression for the stress function χ in bipolar co-ordinates to solve the problem of dislocation in a hollow cylinder whose cross-section is bounded by two non-concentric circles due to (i) parallel fissures and (ii) wedge-shaped fissures.

Ghosh (1930) worked out the solutions of biharmonic equation in elliptic coordinates and applied it to the problem of plane strain. A single-valued solution was found suitable for the case of an elliptic cylindrical cavity in an infinite solid, while another many valued solution applicable to the state of strain in an elliptic cylindrical shell, which had suffered dislocation due to a triangular axial fissure, was also found. Ghosh found that Love's method of solving problems in plane strain in elliptic co-ordinates is only applicable to cases where surface displacements are given. The method developed in Ghosh's paper gives not only Love's solution but also the solution of an infinite solid with elliptic cylindrical hollow subjected to a pressure on the inner elliptic boundary and solution of the problem of dislocation for a wedge-shaped fissure in a body bounded by two confocal elliptic cylinders.

(c) *Plane Problems*—The problem of determination of stress and strain in rotating elliptic cylinders and discs had been worked out by Chree (1892) by using cartesian coordinates. However, the expressions obtained by him are far from being simple. The method of solution of Basu and Sen Gupta (1927), by using elliptic coordinates, is only applicable to slowly rotating cylinders with nearly circular sections. Ghosh (1928) considered the problem as that of a plane stress (for cylinder) and a plane strain (for disc) by solving for the stress-function χ from the equation $\nabla_1^4 \omega =$ constant without any limitations.

The problem, "On the stress and strain in a rolling wheel", was worked out by Ghosh (1933) assuming the wheel to be in a state of generalised plane stress, and solving the stress equation of equilibrium. Solution of "Plane strain in an infinite plate with an elliptic hole," when the surface displacements are given was obtained by Ghosh (1936*a*) by using the form of the stress function in elliptic coordinates. "Stress distribution in a heavy circular disc held with its plane vertical by a peg at the centre" was discussed by Ghosh (1936*c*). He considered the disc to be in a state of generalised plane stress. Stress-function χ is determined in two cases : when the peg is assumed (i) to be rigidly fixed to the disc so that it exerts a thrust on the disc across the upper half of the common boundary and tensions across the lower half and (ii) to be so inserted in the circular hole, so that the peg exerts tractions on the disc only across the upper half of the common boundary. Interesting cases of "Generalised plane stress in heavy circular disc," were considered by Ghosh (1936*c*). In the first case, considered in this paper, the stress-function suitable for heavy circular disc with a concentric circular hole resting vertically on a horizontal plane is determined. This applies to the case of a wheel to which a load is applied by an axle fitting into it, by prescribing suitable tractions on the inner boundary.

In 1937, an investigation was initiated by Ghosh for the solution of equations of generalised plane stress in a semi infinite plate with a singularity at a specified point arising from a couple acting on the plane of the plate.

The solution of the problem for a single circular hole in an infinite plane under tension is well-known, but it is seen that the presence of adjacent holes or boundaries complicates the situation. Bipolar co-ordinates were used by Ghosh (1939) to find "The stress distributions in an infinite plate containing two equal

circular holes," when it is subjected to (i) a uniform tension in the direction of the line of centres, and (ii) a uniform shear in the plane of the plate.

Ghosh (1942) investigated the problem, "On plane strain and plane stress in aeolotropic bodies." Earlier, Haber (1938) had obtained the equation satisfied by the stress function assuming the aeolotropic plate to be in a state of generalised plane stress. Green and Taylor (1939) further simplified the equation assuming that the material of the plate had two directions of symmetry at right angles to each other in the plane of the plate. However, no justification had been given by the above authors for the simplifying assumptions made by them. Ghosh (1942) examined the fundamental question whether an aeolotropic body could at all be in a state of plane strain or plane stress, and if so, under what conditions. Compatibility conditions play an important role in finding the necessary and sufficient conditions for plane strain. It was also observed that these conditions are satisfied in a large class of bodies and particularly in materials with three perpendicular planes of symmetry, one of which coincides with the plane of the plane strain. Ghosh also examined the case of plane strain for bodies with three perpendicular planes of symmetry at each point, one of them coinciding with the plane of plane stress and found that only possible stress functions in plane stress in the X-Y plane are polynomials of the sixth degree in X, Y. Such stress functions can only give rise to particular distributions of tractions on the rim of the aeolotropic plate so that the assumption of plane stress under an arbitrary distribution of surface tractions on the rim cannot be warranted.

Solutions are given of some simple problems of plane stress including that of the bending of a rectangular aeolotropic plate by couples applied to the rim. In continuation of the above paper, Ghosh (1943), found that a state of plane stress cannot in general, exist in the plate, if such a material with its plane faces parallel to one of the planes of symmetry be subjected to arbitrarily prescribed traction on its rim. He also solved some examples of plane stress that could occur in the plate requiring traction on the rim, to be distributed in some restricted manner. The distribution of stress in a rotating aeolotropic disc with a circular or elliptic boundary was also considered. It was found that the solution of the partial differential equation of the fourth order satisfied by the stress function which is not homogeneous leads to the strain function being a polynomial of the fourth degree in X, Y and quadratic in Z. It was also seen that the expression for the stress function satisfies the condition imposed for the existence of a plane stress in the plate. Ghosh's paper (1946*c*), "On Generalised plane stress" examines the possibility of a state of generalised plane stress in a plate of aeolotropic material with the planes of symmetry, the plane face of the plate being parallel to one of the planes of symmetry. The components of stress have been expressed in terms of two stress functions χ and ψ. It is deduced that it satisfies two homogeneous linear partial differential equations of the sixth order which are not in general compatible unless it is a polynomial of a degree not higher than eighteen in X, Y, Z. It is thereby concluded that a state of generalised plane stress is, in general, not possible in such a plate.

Ghosh (1946*a*) critically examined the assumptions made in solving the problem of the plate being stretched and bent by forces acting along its cylindrical edge.

He found that in the flexure of a plate, a state of generalised plane stress is always possible while only a restrictive distribution of deforming forces and couples could lead to a state of plane stress. It was also pointed out that in the stretching of a plate by forces in its plane, a state of plane stress could always be found while the existence of a state of generalised plane stress has not been proved He further found that the problem of average stresses can not be solved unless suitable assumption is made about Z_z which occurs in the expression for average stresses and average displacements. It was shown that the most general value of Z_z is a plane harmonic function, or the average value of the product of a harmonic function by X or Y or Z or γ^2.

Ghosh (1946*a*) also criticised that the solution of the problem of Filon (1903) by taking $Z_z = 0$ identically and $X_z = Y_z = 0$ on the boundary plane, $Z = \pm h$, leads to the vanishing of X_z and Y_z identically. Hence, Filon's solution is not of generalised plane stress, but one of plane stress.

Southwell (1936) gave a solution of stress equation of equilibrium which satisfies the conditions of compatibility of stress and the condition $Z_z = 0$. Ghosh pointed out that in the above solution, Southwell had not taken account of the condition that the plane faces of the plate are free from tractions.

In his paper entitled, "On the concept of generalised plane stress in an aeolotropic plate," Ghosh (1946*c*) gave an exact solution of stress equation of equilibrium satisfying the stress compatibility relations as well as boundary conditions on the plane faces of the plate, thus proving the possibility of a state of generalised plane stress in the plate. The appropriate surface tractions which are to be applied to the edge of the plate to maintain generalised plane stress were also calculated by him.

Ghosh in a paper (1944) concludes that an infinite elastic solid cannot be in a state of plane strain when forces are distributed uniformly perpendicular to several infinite parallel straight lines, the forces on each line being in a definite direction, unless the algebraic sums of the components of the forces per unit length of the lines along two perpendicular directions at right angles to them vanish. He also observed that when an infinite plate is deformed by forces in its plane acting at given points, the average stress and displacements in the plate can be obtained from the analogous plane strain problem provided the forces acting on the plate at the given points are either in equilibrium or reduce to a couple.

Solution of Laplace's equation suitable for the problem when the boundaries are two spheres touching each other was obtained by Ghosh (1936*d*).

(d) *Vibration of Ring*—Free vibrations of a rod which in the unstressed state forms a circular ring have been discussed by several writers after the 'rotating inertia' terms have been neglected from the equations of motion. Ghosh (1935*b*) examined the retention of these terms to the period of vibration and observed that as the number of wavelengths in the circumference increases, this correction increases in importance in the flexural vibrations while it is small and remains practically stationary for torsional vibrations.

Ghosh (1936*b*) gave certain solutions of equilibrium equations in three dimensions on the assumption that the displacement is inversely proportional to

r^2 and determined the distribution of stress in a cone to which a couple is applied at the vertex.

(e) *Torsion and Flexure Problem*—Ghosh (1935*a*) gave a solution of the flexure problem for a beam whose cross-section consists of (1) a semi-ellipse bounded by its minor axis and (2) an ellipse and two confocal hyperbolas. The second one was reduced to the interesting case of an elliptic beam with two cracks extending the foci to the boundary of the ellipse along the major axis.

Torsion of a solid of revolution of a material possessing curvilinear aeolotropy was solved by Ghosh (1956).

Pioneering work had been done by Ghosh (1947, 1948) in solving torsion-flexure problems by the use of function theory. It has opened out the possibility of solution of a new class of boundaries.

The use of complex function had been made by Stevenson (1938–39). Morris (1940) had also used complex variables in solving some general types of sections. Ghosh observed that Stevenson's subdivision of the problem into six Dirichlet or Neumann problems, when the origin is not at the C. G. is defective in as much as the six flexure functions introduced by him are not free from infinities. In Morris's solution, the series she makes use of are not all convergent within the cross-section.

Solution of the torsion problem of isotropic elastic cylinder proposed by Muskhelisvili (1929) by function-theoretic method is of remarkable simplicity ann elegance. No attempt had yet been made to apply function-theoretic method to the solution of the flexure problem. The boundary condition in the flexure problem when formulated as a Dirichlet one is not simple. Ghosh (1947*a*) simplified the problem by subdividing the flexure function into three simpler Dirichlet functions f_0, f_1, f_2 with boundary conditions of their imaginary parts ψ_0, ψ_1 and ψ_2 as

$$\psi_0 = \tfrac{1}{2}\,(x^2 + y^2),\quad \psi_1 = \int_A^P [(1+\sigma)\,x^2 - \sigma y^2]\,dy + \text{const.}$$

$$\text{and}\quad \psi_2 = -\int_A^P [(1+\sigma)\,y^2 - \sigma x^2]\,dx + \text{const.}$$

For such a sub-division to be possible, it is essential that the origin should be taken at the C. G. of the cross-section. The orientation of the load line in the terminal cross-section has been taken rather arbitrarily.

The boundary condition is—

$$\psi_2 + i\psi_1 = \tfrac{1}{12}\,(1+2\sigma)\,z^3 - \tfrac{1}{4}\,z\bar{z}^2 + \tfrac{1}{2}\,(1+\sigma)\int_A^P \bar{z}^2 dz$$

The analytic functions f_1 and f_2 are then expressed as :

$$f_1 = \tfrac{1}{12}\,(1+2\sigma)\,z^3 + f_{11} + (1+\sigma)\,f_{12},$$

$$f_2 = \tfrac{1}{12}\,(1+2\sigma)\,iz^3 + f_{21} + (1+\sigma)\,f_{22},$$

where $f_{11}, f_{21}, f_{12}, f_{22}$ are obtained from the second and third term respectively of the expression for $\psi_2 + i\psi_1$.

The solution using $z = \omega(\sigma)$, the formula mapping the region conformally into the unit circle γ has been finally obtained by using Schwarz's formula as—

$$f_0 = \frac{1}{2\pi} \int_r \frac{\omega(\sigma)\,\bar{\omega}\,(1/\sigma)}{\sigma - \rho}\, d\sigma$$

$$f_{11} + i f_{21} = \frac{i}{2\pi} \int_r \frac{[\omega(\sigma)]^2\,(\bar{\omega}\,1/\sigma)}{\sigma - \rho}\, d\sigma$$

$$f_{11} - i f_{21} = \frac{i}{2\pi} \int_r \frac{\omega(\sigma)\,[\bar{\omega}\,(1/\sigma)]^2}{\sigma - \rho}\, d\sigma$$

$$f_{12} + i f_{22} = -\frac{i}{2\pi} \int^{\rho} d\rho \int_r \frac{[\omega(\sigma)]^2\,\omega'\,(1/\sigma)}{\sigma^2\,(\sigma - \rho}\, d\sigma$$

$$f_{12} - i f_{22} = -\frac{i}{2\pi} \int^{\rho} d\rho \int_r \frac{[\bar{\omega}\,(1/\sigma)]^2\,\omega'(\sigma)}{\sigma - \rho}\, d\sigma$$

The coordinates of the centre of flexure had also been obtained by Ghosh. Utilising Ghosh's method (1947–48), Dr D. N. Mitra, the first research associate of Dr Ghosh, continued this line of investigation. Mitra (1948) solved the problems of torsion flexure for (i) inverse of an ellipse, (ii) two orthogonal circular arcs and (iii) loop of leminiscate of Bernoulli. Subsequently, he worked out the cases of the flexure of limacon (1949*c*) flexure of cross-section bounded by two closed curves (1952) and the torsion of composite sections (1955), in succession.

Development of the function-theoretic method reveals his remarkable mathematical ability, when Ghosh solves the torsion problem (1947*b*) and flexure problem for boundaries (1948*a*) which consist partly of as traight line by extending the theory propounded in his paper (1947*a*). In such cases, the function mapping the region conformally on the unit circle is very complicated while the function which maps the cross-section conformally on a semi-circular area is simple, the straight boundary of the cross-section corresponding to the boundary diameter of the circle. The problem is then reduced to the determination of a function of ρ analytic within the semi-circular area and real on the bounding diameter, its imaginary part taking up prescribed values on the semi-circumference. By Schwarz's principle of reflection, this function is continued analytically to the other half of the unit circle so that the problem becomes one of determination of a function analytic within the unit circle and its imaginary part takes up prescribed values, on the circumference. This function is then determined with the help of Schwarz's formula. The method has been extended by Ghosh (1948*b*) to "Torsion and flexure of a beam whose cross-section is a quadrant of a given area," symmetrical about two particular axes and which can be mapped conformally on the unit circle by a function of a simple form. The solution of torsion-flexure problem depends

in this case on the determination of a function analytic in the region and whose imaginary part takes up prescribed values at the boundary. This function when continued analytically to other three quadrants of the circle R by Schwarz's principle of reflection is found to be multi-valued in the domain with a branch point at the point of intersection of the axes of symmetry. The part of the function which is multivalued is obtained from the value of the imaginary part of the function on the boundary of the region, and the remaining part of the function is then determined by representing R conformally on the unit circle and using Schwarz's formula for an analytic function within the circle, whose imaginary part takes up given values on the circumference. Using this method, Mitra has solved the torsion flexure of a semi-circular cylinder (1949*a*), semi-cardoid (1949*b*) sector of a circle (1950) and sector of a curve (1951). Bassali (1961) has also used Ghosh's method to solve "torsion of elastic cylinder with regular curvilinear cross-section."

Professor Suddhodan Ghosh made significant contributions to Mathematics and Mechanics. In particular, he was one of the leading research workers in the fields of Elasticity and Fluid dynamics in our country. Many of his papers have been quoted in standard text-books on Elasticity and relevant books of reference. The well-known book entitled, *"Resistance des Materiaux"* by Robert L' Hermite, I, Paris (1954) has treated the problems of Torsion and Flexure as solved by Ghosh and Mitra in great detail.

Among his many research associates, some persons distinguished themselves by following his footsteps like : (1) Professor Debendranath Mitra, Ex-Head of the Department of Mathematics, Indian Institute of Technology, Kharagpur; (2) Late Professor B. Karunes, Ex-Head of the Department of Applied Mechanics, Indian Institute of Technology, New Delhi; (3) Shri Kamini Kumar Dey, (Retd.) Assistant Professor of Mathematics, Presidency College, Calcutta; (4) Dr Jnangopal Chakrabarti, Professor, Department of Applied Mathematics, Calcutta University, Calcutta; (5) Dr Srimati Lakshmi Sanyal, Principal, Sarojini Naidu Girls' College, Calcutta; and (6) Professor Sudhir Khamrui, Reader, Department of Mathematics, Jadavpur University, Calcutta.

Reminiscences of Family and Private Life

Suddhodan Ghosh remained a bachelor for life. He rigidly adhered to the vow of celibacy of the cloister.

After his mother's demise in 1919, a rift appeared within the family. As a consequence he decided to leave his home and sever his ties with the family once for all.

For the rest of his life, he lived alone and aloof from the vagaries of the world, occupying a single-room flat, which he converted into a study-cum-bedroom. His only furniture consisted of three almirahs, a couple of chairs and a wide wooden bedstead piled with books and papers. He seldom used the ceiling fan lest the loose sheets of paper should fly away. He prepared his own meals which consisted of boiled rice and vegetables. Later, he further simplified his food-habits by resorting to milk and bread. He washed his own clothes and utensils and performed

all household chores. Only on rare occasions, during illness, did he engage a servant.

During the long vacations, he visited most of the places of pilgrimage in India. Jokingly, he used to say that by such visits he had assured for himself, a niche in heaven.

When he earned his first scholarship, he promised that he would give away five times the total amount of earned scholarships to charities. He kept his promise. Anonymously, he gave away about a lakh of Rupees to religious, social and charitable organisations like Sri Ramakrishna Mission, Bharat Sevasram Sangha, Mother Teresa's Sisters of Charity, Salvation Army, Red Cross Society etc. He also donated liberally when natural calamities ravaged the country. It should be noted that he did not belong to the class of men who gave away donations merely for recognition. He was one of those who had little and gave it all away. He was a silent donor. He used to say : *"Monotheism is my doctrine. By offering a helping hand, I really help myself."* After giving about a thousand Rupees to a needy friend, he whispered aside, *"I guess I shall be able to sleep more comfortably tonight."* He used to give monthly stipends to needy meritorious students and poor freedom-fighters.

About a week before his death, all the gold medals he had obtained during his brilliant academic career were handed over to the University of Calcutta in deference to his wishes, for the creation of an endowment for providing financial aid to poor and meritorious students of the Department of Applied Mathematics. He also bequeathed to the Asutosh Museum of the University of Calcutta, the valuable Gold Mohur of Akbar's time, he had received from his mother and had retained as a memento.

During a pilgrimage to the Himalayas he had visited the temples of Badrinarayan and Kedarnath. He prostrated himself on the icy floor before Lord Siva at Kedarnath and sought his benediction with the following words : "*Father ! Bestow on me enough strength to stick to my resolution, once it is approved by my conscience, and endow me with the faculty of non-attachment to any mundane favour.*" Verily, he never bent his head before social injustice and stuck to his principles to the very end.

Prosperity never turned his head nor did adversity ever crush his spirit. He took the joys and sorrows of life with imperturbable calm. He had no hankering for pleasant things, nor hatred for evil ones. He did not expect anything, nor did he grieve. He took things as they came, and pursued his path of life with steady, unfaltering steps. Although, everybody was welcome to him for his advice, he never visited any house for social contact. In this sense, he was never social. He was above society or social customs.

In his academic life, he behaved like a true Sanyasi, never requiring more than was needed for his maintenance. He refused to accept head examinerships of the university.

He felt that self-satisfaction was the surest sign of degeneration. He rendered inestimable service to the Calcutta Mathematical Society, and helped to sustain it when it was on the verge of collapse. For a long time, he functioned as its (honorary) Editorial Secretary. Although in later years, he cut off his relations with the society, he was elected its honorary member, a unique distinction.

Honour

He was elected a Fellow of the National Institute of Sciences of India in 1951.

Epilogue

Professor Suddhodan Ghosh retired from the Calcutta University in 1962. He did not seek any extension to his services. He had walked through the politics of his time, touching elbows with his contemporaries as he met and passed them on his pilgrimage through the Department of Applied Mathematics. He knew the obvious realities of his environment.

There was no provision for pension to a retired university teacher. Nevertheless, he got about Rs. 93,000 as his provident fund and gratuity. To Dr Ghosh money was no lure—it was simply something to give away. He rented a single-room flat on the ground floor of 256, Rash Behari Avenue at Rs. 75 per month and reduced his personal expenses to the minimum. An asthmatic afflicted by a weak heart, his life expectancy was poor. And so, he began supporting destitute friends and poor students rather lavishly. His accumulated wealth dwindled rapidly. At this critical juncture, a friend came to his rescue. He withdrew the remaining money from the bank and kept it under his personal custody as a trustee. He gave Dr Ghosh a monthly allowance of Rs. 300 only for his personal expenses.

During the initial years after his retirement, Dr Ghosh was agile and vivacious. He took long walks into the country, enjoying its scenic beauty. His interest in literature was deep. Tagore was his favourite author. He also enjoyed reading books of Tolstoy, Goethe, Victor Hugo, Dickens and George Bernard Shaw.

With declining health, his life became slower, more austere and introspective. As his eyesight progressively deteriorated, he confined his activities within the four walls of his room. A friend suggested the surgical removal of cataracts from his eyes. He refused. His reply was characteristic. He said, "All my life I have seen and enjoyed the beauty of the external world. At its fag end, I am interested in exploring the inner world. For this purpose, physical eyesight is not necessary."

He suffered in silence, but never expressed his anguish in words. To any casual enquirer about his health, his usual answer was : "I am extremely well. God has taken special care of me." His concept of Providence is revealed in the following tete-a-tete which he once had with his philosopher friend, Dr Tripurari Chakravarti, a frequent visitor.

Dr C : "Dr Ghosh, do you really believe that God exists?"
Dr G : "Yes, I do."
Dr C : "How do you know? Have you ever seen Him?"
Dr G : "No, I have not seen Him visually. And yet, I have felt His existence in my heart. It is not necessary to visualise everything to believe in its existence. I have never visited England. Does that mean that England never exists?
The ancient Indian sages emphatically maintained that they had realised God within themselves. How can I disbelieve them?"

And then, with a twinkle in his eyes, he smilingly added : "Perhaps His seat is spread in the hearts of a few saints, even as one finds singularities in the analytic regions of Mathematics."

He loved, respected and adored Professor S. N. Bose. The adoration was mutual. On hearing of the demise of Professor Bose, from the present writer, his sightless eyes glistened with tears. He earnestly requested the author to get him a pair of old slippers of Professor Bose. On being asked what he proposed to do with them, he said, *"I shall put them on my head every morning."*

During the evening of his life, with the dark clouds of uncertainty hanging over his mental horizon, Dr Ghosh realised two central facts of life : the futility of our efforts, and the tender and loving watchfulness of Providence. During this difficult period when he was practically bedridden, he was fortunate to secure the services of two of his erstwhile pupils, Dr Lakshmi Sanyal, M.A., D.Phil. and Dr Mina Majumder M.Sc., Ph.D. They helped him through crisis and peril and in moments of despair. With genuine affection and unpretentious piety, they adopted the role of little mothers to nurse this great man and kept close company with him till his death.

About a week before his passing away, he gave away all his earthly possessions; books, papers, furniture money and gold medals. Earlier, he had given away anonymously about a lakh of rupees to different social and charitable organisations. Now he distributed his books and papers among friends and pupils. In particular, he presented O. W. Richardson's Electron theory of Matter to the present writer, who was amazed to find the signature of Ernest Rutherford, 1919, on its cover slip. It is amazing how the book found its way into the Calcutta second-hand book market !

He died as he had lived—bravely and quietly on May 6, 1976. His last rites were performed by Bharat Sevasram Sangha. To his two beloved pupils, to his friends who knew and loved him and to numerous admirers who sorrowed at his death, he left behind the shining legacy of courage, righteousness and profound scholarship.

Acknowledgements

The author is deeply indebted to Professor D. N. Mitra for the comprehensive coverage of Professor Suddhodan Ghosh's research activities and his contributions to new knowledge. His sincerest thanks are also due to Dr Shrimati Mina Majumder for compiling the Bibliography and for revealing anecdotes about the saintly character of her teacher.

S. D. Chatterjee

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K. V. Krishnan

KUMARAPURAM VYTHILINGA KRISHNAN

(1896–1978)

Foundation Fellow 1935

KUMARAPURAM VYTHILINGA KRISHNAN was born on July 4, 1896, in a Brahmin family of Thali, a suburb of Calicut in Kerala. He was the seventh child of his parents and that is the reason for his bearing the name Krishnan according to the local tradition associated with the birth of Lord Krishna. He had four brothers and two sisters elder to him besides a younger brother and a sister. Only the younger brother and one of the elder sisters survived him. One of his forbears, Vythilinga Sastry, was a noted Sanskrit scholar and served as priest in the Hindu temple, *'Vaitheeswaran Koil'* in Thanjavur District. He left this temple with his rather large family to settle in Chithur in the Kerala State where he received support from the Rajah of *'Palghat'*. Dr Krishnan's father, Vythilinga Venkateswaran, was supposed to have inherited some lands but promptly lost them while trying to do business. This jeopardised Krishnan's education to some extent, but with the help of his mother Shrimati Subholakshmi and that of a philanthropic relative he was able to complete his graduation in Medicine from the Madras Medical College.

MARRIAGE, WIFE, CHILDREN AND REMINISCENCES OF PRIVATE LIFE

Krishnan was married to Shrimati Visalakshmi Ammal, grand daughter of Rao Sahib K. D. Subrahmanya Iyer as well as of Justice Ranga Iyer, Chief Judge of Travancore High Court. They had four children—a son and three daughters. The son, Chama Krishnan, is a pharmaceutical chemist. The eldest daughter *Rance* is married to Dr R. Subrahmaniam, now retired as Director of Health Services of Madhya Pradesh. The second daughter, Sorojini, was married to Shri P. S. Narayan who died prematurely leaving two sons and a daughter. The third daughter of Dr Krishnan, Lalitha, is an M. A. in Philosophy and is now in the U.S.A. with her husband.

After the death of his first wife in 1941, Krishnan married Ivy Massih, a talented doctor in the Women's Medical Service. She was Professor of Pharmacology in the Lady Hardinge Medical College, New Delhi, and subsequently in the Cuttack Medical College. She also died almost simultaneously with Dr Krishnan. Dr Krishnan died of sudden heart attack on his telephone desk while trying to contact the hospital where his wife had been admitted earlier. Neither knew the death of the other.

Medal" in appreciation of his meritorious work in the teaching of Preventive Medicine and Public Health in that country, but WHO regulations prevented his receiving it.

Special Lectureships

He was selected to deliver the following special lectures : (i) Maharaja of Burdwan Lecture on *Malaria Problem in India,* (ii) Brahmachari Lecture on *Immunity in Tropical Diseases,* (iii) Dutta Memorial Lectures on *Recent Advances in Allergy,* (iv) Dr Lakshmanaswamy Mudalier Lecture on *Typhus Fevers in India,* (v) Andhra University Extension Lectures on *Transmission of Kala-azar and Typhus infection and Allergy in Medicine.* He also delivered lectures on protein hydrolysate in several institutions on invitation.

Membership of Scientific Societies and Advisory Committees

Besides Fellowships of high ranking scientific societies mentioned earlier, Dr Krishnan was a member of the Public Health Society of India (now defunct), Indian Association of History of Medicine, Madras, Advisory Committees of the Indian Council of Medical Research. He also visited U.S.S.R. and China as member of medical delegations.

Dr Krishnan was not only an eminent medical scientist but also a good teacher and an eloquent speaker. He had a very successful career both as a researcher and as a teacher and served the country with devotion. He also endeared himself to all students, colleagues and others with whom he came in contact. He passed away on March 30, 1978, almost simultaneously with his second wife, at the age of 82.

S. C. Seal

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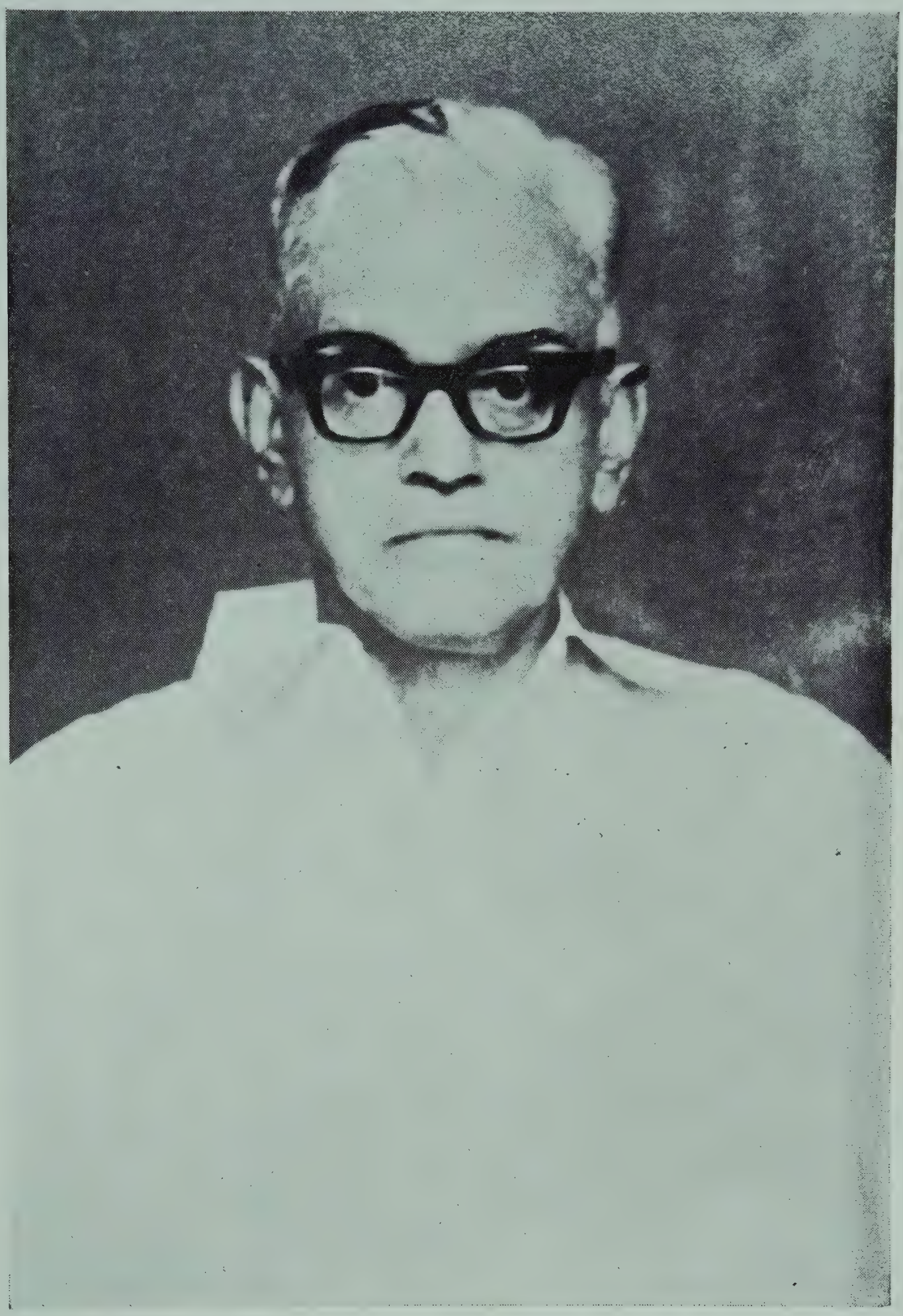
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C. T. Rajagopal

CADAMBATHUR TIRUVENKATACHARLU RAJAGOPAL

(1903–1978)

Elected F.N.I. 1964

MANY who knew C. T. Rajagopal could not believe that he was no more on April 25, 1978. He was so healthy and was so regular in habits that nobody could believe that destiny would snatch him away so soon. The end was painless and his wife who was by his side could not believe that he had left her. A medical man, who was called by her, when her beloved husband stopped responding to her enquiries, declared him to have succumbed to a "massive heart-attack."

BIRTH AND EDUCATION

Rajagopal was born to Cadambathur Tiruvenkatacharlu and Padmamma, on September 8, 1903. Thiruvenkatacharlu, as his name indicates, spent most of his life in the Telugu-speaking areas of composite Madras State of those days, serving the Revenue Department with quasi-judicial duties. Rajagopal was the eldest son, with two younger brothers and a sister of whom one brother and the sister survived him. His aged mother, who survived Rajagopal breathed her last a few months later. Rajagopal and his brother Venugopal, whose official names were, however Raju and Venu, respectively, were well known in Triplicane for their high degree of proficiency first as students of the Hindu High School and later, of the Madras Presidency College. He matriculated in the year 1919 and passed the Intermediate Examination of the University of Madras in 1921, both with high marks. He took the B.A. (Honours) Course in mathematics the same year but postponed writing the final examination by one year because of illness. He passed the B.A. (Honours) Examination obtaining the first rank in the then Madras Presidency in the year 1925. It was during the B.A. (Honours) course that he came into contact with K. Ananda Rau, who was Professor of Mathematics in the Presidency College. Clearly, Ananda Rau made an indelible impression on Rajagopal, which lasted throughout his life. In fact, there is an interesting parallel between the careers of these two men, which begins even earlier than their first contact, viz., their highly proficient studentship in the two renowned institutions, the Hindu High School and the Madras Presidency College. Ananda Rau could notice the "exceptional intelligence" of young Rajagopal. It is noteworthy that T. Vijayaraghavan, who influenced Rajagopal later in his career, was a senior college mate of his in the Honours classes.

Professional Career

Rajagopal worked for more than a year in the Madras Accountant General's Office but left it to begin his teaching career in the Annamalai University in 1930–31. He later moved to the Madras Christian College and served that college for two decades till 1951. It is here that his lucid and often original exposition of classical mathematical analysis and his tender care for students, in which he was in full measure supported by his wife, Rukmini, whom he married in the year 1925, won for him their everlasting admiration, affection and respect. He built a house at Tambaram according to his own design and settled down, as he thought at that time, and named his abode "The Anchorage," teaching mathematics and doing research. Unlike many of Ananda Rau's students, Rajagopal started his research work late, some 14 years after his graduation. His initial papers were a prelude to what he was to take up for research and reflected his original exposition of topics which he taught for the honours classes.

At the Ramanujan Institute of Mathematics, Madras

The year 1951 was really a turning point in Rajagopal's life. By then Vijayaraghavan had taken up the headship of the Ramanujan Institute of Mathematics founded in 1950 by the late Alagappa Chettiar,* a well-known educationist. Vijayaraghavan succeeded in persuading Rajagopal to join the Institute. Rajagopal yielded readily to the persuasion of his great friend. However, the sudden and unexpected demise of Vijayaraghavan in 1955 left Rajagopal in sole charge of the responsibility of keeping alive "a small remembrance of a great man" as Alagappa Chettiar described the Ramanujan Institute. Thereafter, Rajagopal's life was a reflection of the vicissitudes in the history of the Ramanujan Institute. Professor Rajagopal was well known by this time and was affectionally called CTR by his students and as Raju by those who were close to him.

After Vijayaraghavan's demise CTR was made Director of the Ramanujan Institute of Mathematics by Dr Chettiar on the advice of Professor Andre Weil and on the opinion of eminent mathematicians like R. P. Boas (Jr.) and A. Zygmund. Later, when the fate of the Institute hung on the balance, the intervention by the famous astrophysicist Professor S. Chandrasekhar made the then Prime Minister Jawaharlal Nehru make a recurring grant to the Institute and transfer its management to the University of Madras. The Institute retained its separate identity till 1967 when it became enlarged, with the University Department of Mathematics merging with it, to become the Ramanujan Institute for Advanced Study in Mathematics. Rajagopal's contribution to the Institute attaining the supreme position as one of the most important centres of mathematical research in India was immeasurable. Professor Rajagopal who was due to retire in 1965 on

*Sir Rm. Alagappa Chettiar, Industrialist and Philanthropist was responsible for the development of Karaikudi as a major educational Centre. It was his offer of 500 acres of land from his Estate and a grant of Rs. 15 lakhs which resulted in the establishment of the Central Electro-Chemical Research Institute at Karaikudi.

superannuation was given an extension of service and continued to be head of the enlarged Institute. It should be mentioned that before all this was achieved, the Institute passed through many a crisis and was often threatened with closure. That is survived those gloomy and agonizing days was as much due to the high quality of mathematical activity generated by CTR as it was to the indefatigable persistence, faith and hope with which he went on representing its cause to the authorities. He finally retired from the Institute in June 1969 but continued his research work with a small financial assistance through the Institute. It is no exaggeration to say that the Institute, as it stands today, is a monument to the unremitting efforts of Rajagopal as it is to the memory of Srinivasa Ramanujan. It is also true that the Ramanujan Institute is finding it difficult to face, with courage, the assessment of its achievements because of the void created by CTR's retirement. The research work of the Institute was during Rajagopal's time, so productive and significant that his passing away has created a vaccum in the country among active, hard analysts, of whom he was perhaps the last.

Contribution to Mathematics

The classical branches in every field of research are always the more difficult to work in, since original ideas are scarce. Rajagopal's main fields of research were summability methods and complex function theory, specially analytic and entire functions.

That in these classical fields CTR acquired an international reputation speaks for the depth, originality and high quality of his work. A few of his earlier papers were an outcome of his pedagogical innovation. Besides the main fields of his interest mentioned above, in these earlier years he was inspired by an article of C. M. Whish, an officer in the employ of the British East India Company of those days, dating back to 1835. This paper pointed out that the series for sine, cosine and arc tangent, as also better and better approximations for π, are given in certain astronomical texts available in Kerala. Rajagopal took upon himself the task of establishing, to the satisfaction of mathematicians and mathematical historians, that the fundamentals of mathematical analysis were discovered and used in Kerala at least two centuries before Newton and Leibniz. He was assisted in this task by the late Prince Rama Varma of Cochin and his own students.

CTR's papers thus fall under three heads. (i) sequences, series, summability, (ii) Functions of a Complex variable, (iii) History of medieval Kerala mathematics. It is not an easy task to summarize here the contents of all of his numerous papers. What follows is an account of that part of CTR's work which he himself considered, in his own modest opinion, interesting and representative of his work.

Sequences, Series and Summability

Rajagopal's work in this field is well indicated in the only treatise on the topic by G. H. Hardy (*Divergent Series,* Oxford, 1949, especially in the notes to § 7.7), in the compendium by K. Zeller (revised later with the collaboration of

W. Beekmann) (*Limitierungsverfahren,* Springer, 1Edn. 1958, 2Edn. 1970) and in the monograph entitled *"Typical Means"* by K. Chandrasekharan and S. Minakshisundaram (Published by the Tata Institute of Fundamental Research Bombay : Oxford, 1952). About a dozen of his papers related to the generalization and/or unification of the several tests for convergence for series of positive terms—without explicit connexion with summability. These provided the undercurrent for the theme of generalization and unification of Tauberian theorems which was to be the main theme of Rajagopal. CTR began his work in summability methods in a note entitled : on 'converse theorems of summability' with the plea that his note "did not merit attention of workers in the field of summability." That this was an expression of Rajagopal's characteristic modesty** is revealed by the attention which G. H. Hardy directed to it in his favourite (according to his collaborator J. E. Littlewood) treatise (*loc. cit.*). It is worthwhile tracing the history of this first research paper of CTR's.

It is well known [*see* Hardy, *loc. cit.,* 121, Theorem 64] that if (s_n) is a real sequence,

$$\frac{s_0 + s_1 + \ldots + s_n}{n+1} \to s,\ s_{n-1} = O_L\left(\frac{1}{n}\right),\ n \to \infty \Rightarrow s_n \to s,\ n \to \infty,$$

or, in other words, if $\{s_n\}$, $s_n = a_0 + \ldots + a_n$, $n = 0,1,2, \ldots$, is the sequence of partial sums of the series $\sum_{n=0}^{\infty} a_n$, then

$$\Sigma a_n = s\ (C, 1),\ a_n = O_L\left(\frac{1}{n}\right),\ n \to \infty \Rightarrow \Sigma a_n = s.$$

With reference to a strictly increasing positive sequence $\{\lambda_n\}$ diverging to infinity one can raise the question : Do we have

$$(\alpha)\quad \lim_{n \to \infty} \frac{\sum_{r=0}^{n} (\lambda_{r+1} - \lambda_r)\, s_r}{\lambda_{n+1}} = s,\ a_n = O_L\left(\frac{\lambda_n - \lambda_{n-1}}{\lambda_n}\right) n \to \infty \Rightarrow \Sigma a_n = s\ ?$$

The first hypothesis on the left side of (α) is what is familiarly known as discrete Riesz summability of type λ_n and order 1 of Σa_n and denoted otherwise by $\Sigma a_n = s(R,\ \lambda,\ 1)$. CTR's result can be stated as

$$(\beta)\quad \Sigma a_n = s(R, \lambda, 1),\ a_n = O_L\left(\frac{\lambda_n - \lambda_{n-1}}{\lambda_n}\right),\ n \to \infty \Rightarrow s = \frac{\nabla \lim s_n}{n \Rightarrow \infty}$$

This result supplements the negative answers to (α) given by K. Ananda Rau [*Proc. London math. Soc.,* (2), **30**(1930), 367–372].

Typical Abel summability (A, λ) is defined by :

$$\Sigma a_n = s\ (A, \lambda) \Leftrightarrow \sum_{n=0}^{\infty} a_n e^{-\lambda_n y} \text{ converges for } 0 < y < \delta$$

$$\text{and}\quad S(y) = \sum_{n=0}^{\infty} a_n e^{-\lambda_n y} \to s \text{ as } y \to +0.$$

**He used to describe himself in official records as the author of some 'thirty independent papers.'

Ananda Rau (*loc. cit.*) proved that

$$\Sigma a_n = s\,(A, \lambda),\ \lambda_{n-1} \sim \lambda_n,\ a_n = O_L\left(\frac{\lambda_n - \lambda_{n-1}}{\lambda_n}\right) \Rightarrow \Sigma a_n = s$$

and he showed that the hypothesis $\lambda_{n-1} \sim \lambda_n$ cannot be dispensed with. CTR established, using a result of Szász [*Trans. Am. math. Soc.*, **39** (1935), 117–130], viz.,

$$\Sigma a_n = s\,(A, \lambda),\ \sum_{r=0}^{n} a_r\,\lambda_r = O_L\,(\lambda_n) \Rightarrow \Sigma\, a_n = s\,(R, \lambda, 1)$$

that the hypotheses on the left of (α) are to be strengthened to obtain an affirmative answer. The following results give the stronger hypotheses required exhaustively and simultaneously for summabilities (A, λ) and $(R, \lambda, 1)$.

(i) $\sum_{n=0}^{\infty} a_n = s\,(A, \lambda)$ or $(R, \lambda, 1)$, $a_n = \mathrm{O}\left(\frac{\lambda_n - \lambda_{n-1}}{\lambda_n}\right)$, $n \to \infty \Rightarrow \Sigma a_n = s$

(ii) $\sum_{n=0}^{\infty} a_n = s\,(A, \lambda)$ or $(R, \lambda, 1)$, $a_n = O_L\left(\frac{\lambda_n - \lambda_{n-1}}{\lambda_n}\right)$,

$$\lim \frac{\lambda_{n+1}}{\lambda_n} = 1,\ n \to \infty \Rightarrow \Sigma\, a_n = s.$$

(iii) $\sum_{n=0}^{\infty} a_n = s\,(A, \lambda)$ or $(R, \lambda, 1)$, $a_n = O_L\left(\frac{\lambda_n - \lambda_{n-1}}{\lambda_n}\right)$,

$$\lim\ a_n \geqslant 0,\ n \to \infty \Rightarrow \Sigma a_n = s.$$

(iv) $\sum_{n=0}^{\infty} a_n = s\,(A, \lambda)$ or $(R, \lambda, 1)$, $a_n = O_L\left(\frac{\lambda_n - \lambda_{n-1}}{\lambda_n}\right)$,

$$a_{n-1} = O_L\left(\frac{\lambda_n - \lambda_{n-1}}{\lambda_n}\right) \Rightarrow \Sigma a_n = s.$$

This sort of exhaustive study of typical summabilities is characteristic of CTR's work as, for instance, his results on the relation of limitation theorems to high indices and on Tauberian theorems on oscillation for (ϕ, λ) method would reveal. Moreover, he gave the precise answer that under the hypotheses in (α) the sequence $\{s_n\}$ of partial sums $s_n = a_0 + a_1 + \ldots + a_n$ has upper limit s. Later, he showed that the Tauberian condition on the left of (α) can be weakened to a slow-decrease type of condition, viz.,

$$\lim_{n \to \infty}\ \inf_{\lambda_n < \lambda_m < (1+\epsilon)\lambda_n} (a_{n+1} + \ldots + a_m) = O_L\,(1) \text{ as } \epsilon \to 0$$

to get the same answer. Again he showed that under the hypotheses on the left of (α) the sequence $\{s_n\}$ converges in λ-density to s in the following sense: A sequence of positive integers is said to have λ-density $\triangle_\lambda$ provided

$$\lim_{x \to \infty}\ \frac{1}{x}\int_0^x S_\nu^*\,(t)\,dt \equiv \triangle_\lambda \text{ exists, where } S_\nu^*\,(t) = 0,\ 0 \leqslant t < \lambda,\ s_\nu^*\,(t) = 1 \text{ or } 0$$

according as ν is or is not in the sequence when $\lambda_\nu \leqslant t < \lambda_{\nu+1}$. A real sequence $\{s_n\}$ is said to converge to s in λ-density if it converges to s through a sequence of positive integers of unit λ-density.

CTR in his work on 'convergence in density' (1957) exploited the notion to obtain an analogue of the classical Wiendr theorem with an assertion of the coincidence of the oscillation limits of two summability transforms as the conlcusion. The culmination of the work inspired by that of his revered teacher, mentioned earlier, found expression in a memorial volume devoted to his teacher K. Ananda Rau, in 1969, edited chiefly by him. In his paper therein, CTR gave a direct proof of the extended form of his result for summability (Φ, λ). The (Φ, λ) transform is

$$(\gamma) \qquad \Phi_\lambda(t) = \sum_{n=1}^{\infty} a_n \Phi(t\lambda_n),\ t > 0,$$

and we are concerned with $t \to +0 \sum_{n=1}^{\infty} a_n$ is said to be summable (Φ, λ) to s when $\Phi_\lambda(t)$ (assumed to exist for $t > 0$) tends to s as $t \to 0$. For the choice $\Phi(u) = (1-u)^k$, $k > 0$, $0 \leqslant u \leqslant 1$, $\Phi(u) = 0$, $u > 1$, (γ) defines the (R, λ, k) transform. In the following general result of Rajagopal, the proof of which utilizes a generalization to summability (R, λ, k) of his result mentioned just above for summability $(R, \lambda, 1)$. Rajagopal has given a conclusive result which is true, of not only the Rieszian transform but also of a general class of transformations which includes the generalized Abel transforms (A_α, λ), $\alpha > -1$, the Riemann transform $(R, \lambda, 2)$ the Stieltjes transform (S, ρ, λ), $\rho > 0$ and the Lambert transform (L, λ).

(I) Let the transform $\Phi_\lambda(t)$ be defined as in (γ) with $\Phi(u) = \int_u^\infty \psi(x)\,dx$ and $\psi(u)$ satisfying the conditions : $\psi(u) \geqslant 0 (u>0)$, $\int_0^\infty \psi(u)\,du = 1$, $\int_0^\infty \psi(u) \mid \log u \mid du < \infty$, $\int_0^\infty u^{ix} \psi(u)\,du \neq 0 (-\infty < x < \infty)$.

Then the condition

$$(\delta) \quad \begin{cases} \lim\limits_{\epsilon \to 0} \lim\limits_{n \to \infty} \min\limits_{\lambda_n > \lambda_m < (1+\epsilon)\lambda_n} (a_{n+1} + a_{n+2} + \ldots + a_m) \geqslant 0, \\ \overline{\lim\limits_{n \to \infty}} \ (\mid a_n \mid - a_n)/2 = h < \infty \end{cases}$$

lead to the conclusion

$$\lim_{t \to 0} \Phi_\lambda(t) = s \Rightarrow \overline{\lim}\ s_n = s - h$$

If (δ) is replaced by either of the two stronger conditions

$$(\delta'') \quad \begin{cases} \lim\limits_{\epsilon \to 0} \lim\limits_{n \to \infty} \min\limits_{\lambda_n \leqslant \lambda_m < 1 = \epsilon)\lambda_n} (a_{n+1} + a_{n+2} + \ldots + a_m) \geqslant 0 \\ \text{and } \lim a_n \geqslant 0 \text{ or } \lim \dfrac{\lambda_{n+1}}{\lambda_n} = 1 \end{cases}$$

$$(\delta'') \quad \lim_{\epsilon \to 0} \overline{\lim_{n \to \infty}} \min_{\lambda_n \leqslant \lambda_m < (1+\epsilon)\lambda_n} (a_n + a_{n+1} + \ldots + a_m) \geqslant 0$$

the conclusion will become :

$$\lim_{t \to 0} \Phi_\lambda(t) = s \Rightarrow \lim_{n \to \infty} s_n = s.$$

Besides these wide and deep generalizations, CTR obtained in his note (1946) on the oscillation of Riesz means of any order precise inequalities involving the Riesz means of orders k and $k+1$ under the hypothesis

$$a_n = O_L\left(\frac{\lambda_n - \lambda_{n-1}}{\lambda_n}\right), n \to \infty,$$

which is one of the hypotheses on the left of (α). These inequalities yield for $k = 0$ the earlier result (β).

Another interesting aspect of Rajagopal's work relating to (Φ, λ) summability is revealed by a sort of converse for high-indices theorems and which generalizes an earlier result of M. C. Austin [*J. London math. Soc.*, **26** (1951), 304-307] for (A, λ) summability.

(II) If the function (u) defining the transform $\Phi_\lambda(t)$ satisfies the conditions imposed on it in (I), and if only series with bounded terms are (Φ, λ) summable, then the highindices condition

$$\lim \frac{\lambda_{n+1}}{\lambda_n} > 1$$

is fulfilled and the series which are summable turn out to be convergent.

CTR's concern for obtaining the most general result in any particular direction is amply illustrated by his treatment of what are now familiarly known as Tauberian constants. To trace briefly the developments in this direction, it is convenient to recall first what Hardy [*Divergent Series*, Oxford, 1949, p. 306, Theorem 238] calls Vijayaraghavan's theorem.

(III) Let

$$\tau(x) = \sum_{n=0}^{\infty} C_n(x)\, s_n, \text{ where } C_n(x) \geqslant 0,\ C_n(x) \to 0,\ x \to \infty,\ \sum_{n=0}^{\infty} C_n(x) = 1,$$

be a totally regular sequence to function transform of the sequence $\{s_n\}$. Then

$$\tau(x) = O(1),\ x \to \infty \Rightarrow s_n = O(1),\ n \to \infty,$$

when

$$\lim_{t \to \infty} \inf_{0 < \Phi(u) - \Phi(t) < \eta} \{s(u) - s(t)\} \geqslant -w,\ 0 < w < \infty \text{ for some } \eta > 0,$$

where $s(t)$ is defined by

$$s(t) = s_n,\ n \leqslant t < n+1,\quad t \geqslant 0,$$

and $\Phi(x)$ is a strictly increasing unbounded function of $x > 0$ such that $\Phi(x+1) - \Phi(x) \to 0,\ x \to \infty$, with

$$\sum_{n=0}^{M} C_n(x) \to 0 \text{ if } M \to \infty,\ x \to \infty,\ \Phi(x) - \Phi(M) \to \infty,$$

$$\sum_{n=N}^{\infty} C_n(x)\,[\Phi(n) - \Phi(N)] \to 0 \text{ if } N \to \infty,\ x \to \infty,\ \Phi(N) - \Phi(x) \to \infty.$$

Summability of $\{s_n\}$ to l by the (τ) transform is the relation $\tau(x) \to l$, $x \to \infty$. The transformation $\tau(x)$ includes the Abel, Borel and Riemann-second-order transformation corresponding respectively to

$$C_n(x) = (1-e^{-1/x}\ e^{-n/x},\ C_n(x) = e^{-x}\ \frac{x^n}{n!},\ C_n(x) = \frac{2}{\pi x}\left\{\frac{\sin\frac{n}{x}}{\frac{n}{x}}\right\}^2.$$

Vijayaraghavan's theorem is a supplement to Wiener's general theorem being useful in deducing the Tauberian theorems with the Schmidt form of Tauberian condition, for instance, for the transformations mentioned just above. Vijayaraghavan's theorem can be interpreted as asserting that certain Tauberian conditions, which make the convergence of $\{s_n\}$ follow from that of $\tau(x)$, make also the boundedness of $\{s_n\}$ follow from that of $\tau(x)$. The class of results which are said to give Tauberian constants, on the other hand, relate the behaviour of $\{s_n\}$ as $n \to \infty$ to that of $\tau(x)$ as $x \to \infty$ through a sequence of values depending in each case on the Tauberian condition selected. The first to investigate this aspect were H. Hadwiger [*Comment. Math. Helv.*, **20** (1947), 319–332] and R. P. Agnew [*Duke Math. J.* **12** (1945), 27–36], who treated the Abel transform. Rajagopal, in some of his generalizations independently of Vijayaraghavan, showed that in the case of the Borel transform $\tau(x) \equiv B(x)$

$$(\epsilon)\quad \lim_{n\to\infty} |B(n) - s_n| \leqslant \left(\frac{2}{\pi}\right)^{1/2} \lim_{n\to\infty} |n^{1/2}(s_n - s_{n-1})|,$$

on the assumption that the right side is finite, the Tauberian constant $(2/\pi)^{1/2}$ being the best possible in the sence that it cannot be replaced by a smaller one. More than the fact that (ϵ) was obtained by Rajagopal, it is important to note that it is a class of summability methods which was treated in each of his papers on the Tauberian series and this class included one or more of the well-known transforms : Abel, Borel, Lambert, Riesz, Stieltjes. In fact, in the last of the series of papers on this particular topic in 1974, Rajagopal indicated how such results not only include results of original Tauber's type but also the Hardy-Littlewood-Wiener type of Tauberian theorems with two-sided Tauberian conditions in the case of a Karamata transform

$$\Psi(x) = \int_0^\infty \Psi(x, u)\, s(u)\, du$$

where $\Psi(x, u) \geqslant 0$ and as $x \to \infty$, $\int_0^U \Psi(x, u)\, du \to 0$ (for fixed U),

$$\int_0^\infty \Psi(x, n)\, du \to 1 \text{ as } x \to \infty.$$

Though R. P. Agnew [*Trans. Am. math. Soc.*, **72** (1952), 501–518] and H. Delange [*Ann. Sci. Ecole Norm Sup.*, (3) **67** (1950), 99–160] studied Tauberian constants, Rajagopal's investigations were extensive.

Another direction in which Vijayaraghavan and Rajagopal extended Vijayaraghavan's theorem is the following :—

If, in that theorem the main hypothesis $\tau(x) = 0(1)$ is changed to $\tau(x) = O_R(1)$ and the Tauberian condition altered to (π) $s_n - s_{n-1} \equiv a_n = O_L(1/g(n))$, $n \to \infty$, where

$g(x)$ is a function depending on the transform and tending steadily to ∞ with x, the conclusion gets altered to $s_n \leqslant C_\tau\ G\ (\log n) + 0(1)$, $n \to \infty$, where $G(x) = \int^x dt/g\ (t) \to \infty$ and C_τ is a Tauberian constant for the summability method τ, the altered conclusion being the best possible in the sense that equality is realized in special cases for a sequence of values of n tending to ∞. Further, a Tauberian condition more restrictive than (π) ensure $\tau(x) \to -\infty \Rightarrow s_n \to -\infty$ as in an earlier result of Vijayaraghavan [*J. London math. Soc.*, **2** (1927), 215–222] for the Abel and Borel transformations. Rajagopal presented this collaborative work posthumously after his friend's demise in 1955 and 1956.

The utility of what are now called product theorems (involving the composition of two summability methods) is well known in Tauberian theory. The earliest utilization of such a theorem, perhaps, dates back [*see* G. H. Hardy, *Divergent Series*, p. 220, Theorem 156] to the Hardy-Littlewood proof of the O–Tauberian theorem for the Borel transform. O. Szasz [*Proc. Am. math. Soc.*, **3** (1952), 257–263) ; *Ann. Polon. Math.*, **25** (1952–53), 75–84] revived the interest in product theorems involving special methods of summability. CTR generalized Szasz's theorems so that the components of the product were either regular sequence-to-sequence or continuous Hausdorff transforms or else power series transforms of the form

$$J\,(x;\ s_n) = \frac{\sum_{n=0}^{\infty} p_n x^n s_n}{\sum_{n=0}^{\infty} p_n x^n}, \quad p_n \geqslant 0,\ 0 < x < \rho,$$

or else integral transforms of the form

$$(\eta) \qquad \Psi\,(t) = t \int_0^{\infty} \Psi(xt)\, s(x)\, dx,\ t > 0,$$

with desirable restrictions on Ψ or even of the form (reducing to (γ))

$$(\omega) \qquad \Psi\lambda(t) = \int_0^{\infty} \phi(xt)\, d[s(x)]$$

when $s(x)$ is the λ-step function

$$s(x) = s_n,\ \lambda_n \leqslant x < \lambda_{n+1},\ n \geqslant 1,$$
$$= 0,\ 0 \leqslant x < \lambda_1,$$

with reasonable restriction on Φ. Most of the familiar transforms are covered by the choices made by him. By combining his product theorem with a 'positive' Tauberian theorem Rajagopal also obtained general Tauberian theorems for the transforms (η) and (ω) yielding well-known theorems in some special cases in 1952 particularly those of Szadśz. The work on product theorems led to collaboration with A. Jakimovski in 1954 providing the latter a starting point for his comprehensive work on the same theme and later with M. R. Parameswaran in 1960, who is currently engaged in exploiting product theorems to simplify the proof of several Tauberian theorems.

R. D. Lord [*Proc. London math. Soc.*, (2) **38** (1935), 241–256] first established a connexion between Borel summability and Cesáro summability of a sequence through a Tauberian condition. His result is : If the real sequence $\{s_n\}$ is summable (B) to s and the nth Cesáro mean of order α, $s_n = O_L(n^{k+1/2})$, $\alpha \geqslant -1$, $k \geqslant 0$, then s_n is summable $(C, \alpha + 2k + 1)$ to s. Rajagopal in his paper connecting Borel and Cesáro summabilities in 1960 showed that the Tauberian hypothesis in the result could be imposed on blocks of terms instead of on individual terms by proving that : if $\{s_n\}$ is a real sequence summable (B) to s and there is a $k \geqslant 0$ for which

$$\lim_{\delta \to +0} \lim_{m \to \infty} \min_{m \leqslant n \leqslant m + \delta \sqrt{m}} \frac{s_n - s_m}{m^k} \geqslant 0,$$

then $\{s_n\}$ is summable $(C, 2k)$ to s. This inspired work of the same kind relating to other methods of the "Circle family" for instance the Meyer-Konig-Ramanujan method (S. α) by Y. Sitaraman *math. Z.*, **95** (1967), 34–49] and an unpublished work of V. K. Krishnan. covering these methods, for the $F(a, q)$ family introduced by A. Meir [*Ann. math.*, (2) **78** (1962), 594–599]. As a matter of fact in 1976. Rajagopal himself considered such a family $F^k(a, q)$ of methods [in conjunction with G. Faulhaber's (*Math. Z*, **66** (1956), 34–52) $V(a,\lambda$ methods)] and obtained the following analogue of a classical result of Knop : If the nth Cesàro mean s_n^p of order $p > 0$ is such that $s_n^p = s + 0(n^{-p/2})$, then $s_n \to s$ $(F^k(a, q))$.

Rajagopal had also introduced, independently of Jakimovski and almost simultaneously, a method of summability parametrized by $\alpha > -1$. This method, in the case of a functicn defined for $x > 0$, was later [*Compositio math.*, **19** (1968), 167–195] called (L, α) method while its analogue for sequences was called (A_α) method and discussed by Borwein [*Q. J. math. Oxford Ser.*, (2) **9** (1958), 310–316]. Both these methods form scales of methods. Rubel [*Pacific J. math.*, **10** (1960), 997–1107] noticed an interesting feature of the scale of methods (L, α) for functions $s(x)$ bounded in $(0, \infty)$ and Rajagopal adapted this feature, with a simplified proof, for functions bounded on one side in $(0, \infty)$. He further enhanced the utility of the (A_α) method by directly exhibiting how the hypothesis of summability (A) $[(A_\alpha)$ for $\alpha = 0]$ in Tauber's original first and second theorems could be replaced by the weaker assumption of (A_α) summability, $\alpha > 0$. It is pertinent to remark that Rajagopal's conjecture that the weaker (A_α) summability, $\alpha > 0$, could perhaps replace the assumption of Abel summability in most of the Tauberian results has come true because of later work (*see* for instance *Tohoku math. J.*, **16** (1964), 257–269) and most recently in the case of the gap Tauberian theorems too as shown by V. K. Krishnan [*Math. Proc. Camb. phi. Soc.* **78** (1975), 497–500].

S. Minakshisundaram and CTR gave a set of difference formulae applicable to Riez typical methods (R, λ, k) of summability for series of order $k > 0$. These formulae, were obtained independently of L. S. Bosanquet's [*J. London math. Soc.*, **18** (1943), 239–248] somewhat different set of formulae. Both these sets of formulae have been used by their authors for extending certain results of K. Ananda Rau [*Proc. London math. Soc.*, (2) **34** (1932), 414–440] involving the (R, λ, k) methods of order $0 < k \leqslant 1$ to $k > 1$. K. Chandrasekharan and S. Minakshisundaram [*Typical Means*, § 3.8] used Bosanquet's formulae to extend some interesting

converse theorems on the abscissae of summability of general Dirichlet series. These extensions themselves were further extended in simpler as well as more meaningful results of Rajagopal. A typical result is

(IV) Suppose that (*i*) the Dirichlet series $\sum_{n=1}^{\infty} \frac{a_n}{\lambda_n^s}$, $s = \sigma + i\tau$, is summable (R, λ_n, q) for some $q \geqslant 0$ when $\sigma > \rho$, (ii) the sum function $f(s)$ thus defined is regular for $\sigma > \eta$ when $\eta > \rho$ and satisfies the condition $f(s) = O(|\tau|^r)$, $r > 0$, uniformly for $\sigma \geqslant \eta + \epsilon > \eta$, (iii) the coefficients a_n of the Dirichlet series satisfy one of the two conditions

$$\text{(a)} \quad \overline{\lim_{n\to\infty}} \lambda_n \max_{\leqslant \lambda_m \leqslant \epsilon\,\theta(\lambda_n)} \frac{a_n + a_{n+1} + \ldots + a_m}{\lambda_n^{\rho}} = O_R(1).\ \epsilon \to 0,$$

or

$$\text{(b)} \quad \overline{\lim_{n\to\infty}} \lambda_n \max_{\leqslant \lambda_m < \epsilon\,\theta(\lambda_n)} \frac{a_{n+1} + a_{n+2} + \ldots + a_m}{\lambda_n^{\rho}} = O(1),\ \epsilon \to 0$$

where $\theta(x) = x^{1-(\rho-\eta)/r}$. Then the Dirichlet series is summable (R, λ_n, k), $0 \leqslant k < r$, for $\sigma \geqslant \{(r-k)\rho + k\eta\}/r$.

CTR concentrated his attention for some two years (1962–63) on the study of Fourier series. He first refined a Tauberian theorem for multiple Fourier series due to Chandrasekh ran and Minakshisundaram [*Typical Means*, p. 119, Theorem 4.53]. This refinement is incidentally a precise analogue of the best possible result of F. T. Wang [*Proc. London math. Soc.*, (2) **47** (1942), 308–325, Theorem 8] for a single Fourier series, but with a proof which is not quite analogous to that of the latter result. In his work on the Nörlund summability of Fourier series, he obtained a result at a point which includes two apparently different results one of them developed by Fejer, Lebesgue and Hardy [A. Zygmund, *Trigonometrical Series*, Chelsea, 1952, p. 49, § 3.31] and the other by K. S. K. Iyengar [*Proc. Indian Acad. Sci. Sect.* **A18** (1943), 81–87, Theorem II] and J. A. Siddiqi [*Proc. Indian Acad. Sci. Sect.* **A28** (1949), 527–531]. In another paper in 1963, he made a neat generalization of earlier results so as to include results of S. Izumi and G. Sunouchi [*Tohoku math. J.*, (2) **3** (1951), 298–305] and M. Sato [*Proc. Japan Acad.*, **30** (1954), 809–813] for uniform convergence of Fourier series at a point on the one hand and of results about ordinary convergence at a point due to Hardy and Littlewood *Ann. Scoula Norm. Sup. Pisa*, (2) **3** (1934), 43–62] and an extension thereof by W. Jurkat *Math. Z.*, **53** (1950/51), 309–339]. His result after desirable simplifications, without losing generality, is the following : Let $f(t)$ be even, of period 2π, $f(t) \in L(-\pi, \pi)$, $f(t) \sim \frac{1}{2}a_0 + \sum_{m=1}^{\infty} a_m \cos mt$. Suppose that $f(x') - f(x'') = O\left\{\frac{1}{L(1/|x'-x''|)}\right\}$ as x', $x'' \to 0$, where $L(u) \to \infty$, $L(ku)/L(u) = O(1)$ for any $k > 0$ as $u \to \infty$ and further that, as $n \to \infty$,

$$\text{(i)} \quad \sum_{m=1}^{\infty} \frac{|a_m|}{|m-n|} = O\left(\frac{e^{CL(n)}}{n}\right) \text{ for some } C > 0,$$

$$\text{(ii)} \sum_{m=1}^{\infty}{}' \frac{|a_m|}{|m-n|} = O(1),$$

where the dash denotes the omission of the term in Σ corresponding to $m = n$. Then the Fourier series of $f(t)$ is "uniformly convergent" at $t = 0$. We can take for $L(u)$-log (u) as Izumi and Sunouchi (*loc. cit.*) did or $(\log\log u^{\alpha})$, $\alpha > 1$, $(\log u)^{\alpha}$, $0 < \alpha < 1$, $\log\log u$ with (i), (ii) replaced by

$$a_n = O\left(\frac{e^{CL(n)}}{n}\right) \text{ for some } C > 0.$$

Rajagopal's attention was especially directed to (i) gap Tauberian theorems, (ii) high-indices theorems and (iii) the history of medieval Kerala mathematics in the last two or three years before his passing away. To a great extent the interest in these topics shared with him by the author of this memoir has been responsible for this special attention. Both he and the author had been meeting in either his or the latter's residence at least twice a month spending several hours, and a good part, on discussing some problem or other in these topics. The inspiration for the study of topic (*i*) came from the author's [*Publ. Ramanujan Inst.* **1** (1969), 269–281] successful use of an idea of V. I Mel'nik's to unify the slow osciallation type of Tauberian theorems and the gap theorems for certain well known methods of summability such as the Abel, Borel and Lambert. CTR raised the question as to whether we had an analogue of Mel'nik's idea for λ-type methods and this was settled later in 1972. Explicitly, it was proved that if $\Phi_{\lambda}(t)$ is the transform corresponding to one of the typical methods, Abel, Lambert or Riesz, and if

$$A(u) = \sum_{\lambda_n \leqslant u} a_n$$

satisfies the condition

$$\lim_{n\to\infty} \sup_{\lambda_n < u < (1+\delta)\lambda u} |A(u) - A(\lambda_n)| \to 0 \text{ as } \delta \to 0$$

then

$$\lim_{t\to\infty} \Phi_{\lambda}(t) = s \Rightarrow \lim_{u\to\infty} A(u) = s.$$

Further, that if

$$\lim_{n\to\infty} \sup_{\lambda_n < u < (1+\delta)\lambda_n} |A(u) - A(\lambda_n)| = 0 \text{ for every } \delta > 0,$$

$$\lim_{u\to\infty} A(u) = \lim_{t\to+0} \Phi_{\lambda}(t).$$

This result is new for the typical Lambert method though it includes the known high indices theorem for the method due to Levinson [Gap and density theorems, *Am. math. Soc. Colloq. Publ.*, No. 27, (1940)] and is interesting in the absence of any known implication of the form $(L, \lambda) \Rightarrow (A, \lambda)$.

It was Rajagopal who first noticed the connexion between the function Φ introduced by Hardy in the context of Vijayaraghavan's theorem (III *supra*) and gap

Tauberian theorems for the method (τ). In one of the Lemmas in 1969 in his article on 'gap Tauberian theorem's he proved the following general result :

(V) Let the transform $\tau(x)$ be defined as in (III) with an associated function Φ.

If the series $\sum_{n=0}^{\infty} a_n$, $a_n = s_n - s_{n-1}$, $n = 0, 1,2, \ldots,$ $s_{-1} = 0$, has gaps as follows :

$$a_n = 0 \text{ if } n \neq n_k,\ k = 0,1,2,\ldots,$$
$$\Phi(n_{k+1}) - \Phi(n_k) \to \infty, \quad k \to \infty,$$

then under the hypothesis $s_n = O_L(1)$, $n \to \infty$ we have the conclusion

$$\lim_{n \to \infty} s_n = \lim_{x \to \infty} \tau(x).$$

In the special case of the Borel transform $B(x)$, he further proved that under the more restrictive gap condition

$$a_n = 0 \text{ if } n \neq n_k,\ k = 0, 1, 2,\ldots,$$
$$n_{k+1} - n_k > \theta_k n_k^{2/3} \quad (\theta \geqslant 0, \text{ fixed})$$

the less restrictive Tauberian condition $s_n = 0(\exp n^{\alpha})$ for some $\alpha < 1$, $n \to \infty$ leads to the conclusion

$$\varliminf_{n \to \infty} s_n = \lim_{x \to \infty} B(x).$$

The collaborative work of Rajagopal and the author on gap Tauberian results continued almost till the end of the former's life and, in fact, there is a well-prepared MS by both awaiting publication after incorporation of certain valuable contributions of Professor B. Kuttner and making him one of the authors as very much desired by Rajagopal and the author too. It is shown therein that when a transform $\tau(x)$ defines a "Karamata method" of summability with Φ associated as in (III), either the slow decrease type of condition

$$\lim_{\eta \to 0} \lim_{n \to \infty} \inf_{0 \leqslant \Phi(n') - \Phi(n) \leqslant \eta} (s_{n'} - s_n) \geqslant 0$$

or the following gap condition strengthened by a boundedness assumption added to it

$$a_n = 0,\ n \neq n_k,\ \Phi(n_{k+1}) - \Phi(n_k) \geqslant C > 0 \ (C \text{ fixed})$$
$$\lim s_n > -\infty$$

ensure the implication

$$\tau(x) \to s,\ x \to \infty \to s_n \to s,\ n \to \infty.$$

In continuatio of Hirokawa's [*Tohoku math J.*, (2) **7**, (1955), 279–295] work, Rajagopal studied a combination of Riemann and Cesàro methods called the Riemann-Cesàro methods of summability. A λ-type analogue of this concept and another involving the Bessel function was introduced and studied by Rangachari [*Math. Z.*, **88** (1965), 166–183 and **91** (1966), 344–347]. Summability (R, λ, p) of

$\sum_{n=0}^{\infty} a_n$ to s means that $\sum_{n=1}^{\infty} a_n \left(\frac{\sin\lambda_n^t}{\lambda_n^t}\right)^p$ converges for $0 < t < t_0$ and tends to s as $t \to +0$. Here $0 < \lambda_n \uparrow \infty$. When $\lambda_n = n$, B. Kuttner [*Proc. London math. Soc.*, (2) **38** (1935), 273–283] showed that $(\mathring{R}, \lambda_n, 2)$ summability of $\sum_{n=0}^{\infty} a_n$ to s implies its Cesàro summability $(C, 2+\delta), \delta > 0$, to s and hence its Abel summability to the same sum. For λ-type methods Rajagopal and Rangachari showed in 1972 that if $\sum_{n=0}^{\infty} a_n$ is $(\mathring{R}, \lambda, 2)$ summable to s and $\sum_{r=0}^{\infty} (|a_r| - a_r)\lambda_r = O(\lambda_n)\ n \to \infty$, then $\sum_{n=0}^{\infty} a_n$ is (A, λ) summable to s. Kuttner [*Proc. Camb. phil. Soc.*, **75** (1974), 83–94], however, showed that the Tauberian condition was superfluous, by adapting certain techniques of Rajchman and Zygmund [*Math. Z.*, **24** (1926), 47–104] but there are other non-trivial results and among them the one giving the condition

$$\lim_{\eta \to 0} \lim_{n \to \infty} \sup_{\lambda_n \leqslant (\lambda_r < (1+\eta)\lambda_n} \sum_{(r)} (|a_r| - a_r) = 0$$

as a Tauberian conditions for $(\mathring{R}, \lambda, 2)$ summbility of $\sum_{n=0}^{\infty} a_n$ to imply its convergence. This result yields the pure high indices theorem for $(\mathring{R}.\ \lambda, 2)$ summability without the sophistication involved in the later work of Kuttner's.

*Functions of a Complex Variable**

Rajagopal's early results (*see* e. g., *a* paper published in 1945) were on periodic meromorphic functions and were inspired by Ganapathy Iyer's work [*J. Indian math. Soc., N. S.*, **5** (1941), 1–17]. He showed in another paper in 1947 that if $f(z)$ is a periodic integral function of order $\rho > 1$ and

$$f(z) = a_0 + \sum_{n=1}^{\infty} 2\ \{a_n \cos(2\pi nz/\lambda) \pm b_n \sin(2\pi nz/\lambda)\},$$

then the Fourier coefficients a_n, b_n satisfy the condition $a_n, b_n = O(\exp(-n^{\rho^*-\epsilon})$ for all positive ϵ, ρ^* being defined by $\frac{1}{\rho} + \frac{1}{\rho^*} = 1$. He also obtained an analogue of Landau's theorem [*Darstellung und Begrundung einiger neurer Ergebnisse der Funktionentheorie*, Berlin, 1929, §§ 1, 2, 4] on the partial sums of Fourier series and gave a new proof of Carathéodory's inequality and allied results [*see* D. S. Mitrinovic, *Analytic Inequalities*, Springer, 1970, p. 333, 3. 8. 41]. The analogue [*see* note on Poores series 1952] of Landau's theorem mentioned above is that for $f(z) = \sum_{n=0}^{\infty} a_n z^n$ analytic in

*The author owes the review relating to Rajagopal's work on function theory to Professor T. V. Lakshminarasimhan, former student and collaborator of his. The biographical part of this memoir elaborates a notice by Professor Lakshminarasimhan and the author published in *The Hindu* dated June 20, 1978. Most of the details about Rajagopal's family were kindly supplied by Mrs Rukmini Rajagopal.

$|z| \leqslant R$ we have $|\operatorname{Re} s_n(z)| < C \log -nA)^*(r)$ where $s_n(z) = \sum_{k=1}^{n} a_k z^k$ and $A^*(r)$ $= \max |\operatorname{Re} f(z)|$ for $|z| = R$. Using this and Wiman-Valiron technique he obtained (as given in his article on an asymptotic relation between an entire function, its deviation and order, an analogue of a relation, originally given in part by G. Pólya and G. Szegö (*Aufgaben und Lehrsatze aus der Analysis*, Berlin, 1925) and completely by S. M. Shah [*Bull Am. math. Soc.*, **53** (1947), 1156–1163], connecting the growth of the maximum modulus of an entire function $f(z)$, its derivative $f'(z)$ and their order ρ and lower order λ, namely

$$(\xi) \quad \overline{\lim_{r\to\infty}} \log r \{M(r, f')/M(r, f)\} \log r = \lambda^{\rho} \ (0 \leqslant \lambda, \rho \leqslant \infty).$$

He also proved that for an entire function $f(z)$ of order ρ, $0 \leqslant \rho \leqslant \infty$,

$$\lim_{r\to\infty} \frac{(\max |\operatorname{Re} zf'(z)| / \max_{|z|=r} |\operatorname{Re} f(z)|}{\log r} = \rho.$$

The corresponding result with $\overline{\lim}$ replaced by lim and the order ρ by the lower order λ of $f(z)$ is still an open question. Motivated by an advanced problem of H. S. Shapiro [*Am. math. Mon.*, **59** (1952), 45] he also obtained in 1953 the inequality (*see* R. P. Beas, Jr., *Entire Functions*, Academic Press, 1954, p. 7, footnote 1.3a.)

$$f'(z) | \leqslant \frac{2R}{R^2 - r^2} \quad \frac{M(R)}{e}, \ 0 \leqslant |z| = r < R,$$

for the function $f(z)$ regular and non-vanishing in $|z| < R$. In the theory of entire functions, he obtained in 1941 a new proof of Hadmard's factorization theorem and collaborated with Lakshminarasimhan and others in supplementing several results obtained by Lakshminarashimhan, in an attempt by the latter, to investigate the analogues to (ξ) that can be obtained by replacing in (ξ) $M(r, f)$ and $M(r, f')$ by other growth functions associated with an entire function $f(z)$ and its derivative $f'(z)$. It was shown by him and Lakshminarasimhan later in 1970 that if (*A*) (*i*) log $S(r)$ is a non-negative steadily increasing convex function of log r for $r > r_0 > 0$;

(ii) log $S(r)$ is of finite non-zero order ρ and finite type τ; then $\overline{\lim_{r\to\infty}} S_1(r)/S(r)$ $r^{-1} \leqslant e^2 \rho \tau$, where e^2 is the best possible constant.

(B) If we suppose additionally that (iv) there is a constant $O \geqslant 0$ such that

$$S_1(r) \geqslant S'(r) - r^{-1} CS(r)$$

whenever $S'(r)$ exists and is finite, that is, except possibly for a countable set r where $S'(r)$ is to be replaced by $S'_{\pm}(r)$ the right and left derivatives of $S(r)$ then

$$\overline{\lim_{\eta\to\infty}} \ S_1(r) / (S(r) r^{\rho-1}) \geqslant \rho\tau.$$

In the above, one can in particular make the choice $S_1(r) = M(r, f')$. $S'(r) = M(r, f')$, ρ, τ being the order and type of the entire function $f(z)$ and its derivative $f'(z)$. Of course, in this case and some other cases the growth functions $M(r, f)$ and $M(r, f')$ can be replaced by other growth functions such as $I_\delta(r, f)$ and $I_\delta(r, f')$ respectively, where

$$I_\delta(r, f) = \frac{1}{2\pi} \int_0^{2\pi} | f(re^{i\theta}) |^\delta d\theta)^{1/\delta} (0 < \delta < \infty).$$

While e^2 in the inequality in (ii) of (A) can be replaced by the smaller constant e by a different method and with particular growth function. Rajagopal was interested in similar results connected with the growth functions $M(\sigma, f)$, $M(\sigma, f)$ of an entire function $f(s)$ represented by an absolutely convergent Dirichlet series given by

$$f(s) = \sum_{n=1}^{\infty} a_n e^{\lambda_n s} \text{ with } s = \sigma + it,$$

$$\lambda_{n+1} \geqslant \lambda_n > 0, \lambda_n \to \infty \text{ as } n \to \infty \text{ with}$$

$$\text{(A) either } \overline{\lim_{n \to \infty}} \frac{\log n}{\lambda_n} = D < \infty$$

$$\text{(B) or } \overline{\lim_{n \to \infty}} \frac{\log n}{\lambda_n} = \epsilon = 0$$

and

$$M(\sigma, f) = \sup_{-\infty < t < \infty} | f(\sigma \pm it) | .$$

In collaboration with A. R. Reddy, he showed in 1965, for instance,

that if $\rho = \overline{\lim_{\sigma \to \infty}} \frac{\log \log M(\sigma)}{\sigma}$ and $\lambda = \underline{\lim_{\sigma \to \infty}} \frac{\log \log M(\sigma)}{\sigma}$, and

$$\mu(\sigma) = \max_{n \geqslant 1} | a_n e^{(\sigma + it)\lambda_n} \text{ and}$$

$$\rho_* = \overline{\lim_{\sigma \to \infty}} \frac{\log \log \mu(\sigma)}{\sigma}, \lambda_* = \underline{\lim_{\sigma \to \infty}} \frac{\log \log \mu(\sigma)}{\sigma},$$

then under condition (*A*)

$$\text{(i)} \quad \rho = \rho_*, \quad \lambda = \lambda_*,$$

$$\text{(ii)} \quad \overline{\lim_{\sigma \to \infty}} \frac{\log \left[\frac{\mu'(\sigma)}{\mu(\sigma)} \right]}{\sigma} = \rho \text{ wherein}$$

$$\mu'(\sigma) \text{ refers to } f'(s) = \sum_{1}^{\infty} a_n \lambda_n e^{\lambda_n s}.$$

He established with Reddy again that historically and, of course, even otherwise important functional equation

$$(C)\quad g(z+w)-\lambda_g(z)=f(z),$$

where $f(z)$ is an entire function of order ρ $(0<\rho<\infty)$ and type σ $(0\leqslant\sigma<\infty)$, with w, λ non-zero constants, real or complex, had a solution with $g(z)$ entire, of order ρ and type λ. This was by way of setting right V. Krishnamurthy's [*Proc. natn. Inst. Sci. India,* Part A, **26** (1960), 642–655] defective proof of the same result by functional analytic methods to which Ganapathy Iyer drew his attention. After about two years, he added an addendum on a suggestion by Professor H. S. Shapiro which was in the nature of a self contained proof of his solution of the functional equation (C).

History of Medieval Kerala Mathematics

As stated earlier, taking the clue from an article by C. M. Whish [*Trans. R. asiat. Soc. Great Br., Ireland* **3** (1935), 509–523] Rajagopal, with the help of competent collaborators presented in two papers first in 1944 and later in 1949 (for the first time) satisfactory modern forms of the proofs of the three series named below, carefully moulding the proof, upon their originals in *Yuktibhasa,* a work in sanskritised form of Malayälam.

(*a*) Gregory's power series for arc tan x (1671 A.D.),

(*b*) Newton's power series for sin x, cos x (1670 A.D.).

A good summary of this work is given in the following two books on history of mathematics : J. E. Hofmann, *Geschichte der Mathematik,* 2nd edn., Berlin, 1963, I; and A. P. Juschkewitsch, *Geschichte der Mathematik in Mittelalter,* Leipzig 1964. The latter book contains an "unusually" (as with western work on history) thorough and up-to-date account relating to Near and Far East. Western prejudice to claims of contributions of the Orient goes even to the extent of blacking out the claims. In this context to contrast with B. Boyer's [*A History of Mathematics,* Wiley,(1968), 246–47] passing mention of "one of the reminders that mathematics owes to India," "the trigonometry of the sine function," and his mere listing of Hindu mathematics in a bibliography, it is worth recording what the Cambridge mathematical historian D. T. Whiteside has written in his monumental and valuable edition of the *Mathematical Papers of Isaac Newton,* **II,** Cambridge 1968, p. 237 Footnote (112) : These series for the sine and cosine, which here appear for the first time in a European manuscript, had, as we now know, already been displayed in a 1639 Malayalam compendium, the *Yuktibhasa,* which itself professes to be based on anearly sixteenth-century Sanskrit original, the *Tantrasangraha,* perhaps the work of the little-known Hindu mathematician Nilakantha (*see* A. R. A. Iyer's and R. Tampuran's modern Malayalam edition of the first part of the *Yuktibhasa* (Trichur, 1948) : 204 f.; and its review by C. T. Rajagopal and A. Venkatraman in [*Math. Rev.*, **12** (1951)], 309–310] The latter manuscript is still unpublished]. The Hindu approach, which depends for example, on repeated iteration of the identity.

$$.\sin x=\int[1-\int\sin\ x dx]dx,$$

is both wholly distinct from Newton's and was described in Europe only in the

early nineteenth century (C. M. Whish,* 'On the Hindu Quardrature of the circle and the Infinite series of the proportion of the circumference to the diameter exhibited in the four sastras...,' *Trans. R. asiat. Soc. Gr. Br., Ireland,* **3** (1835) : 509–523), so that there can be no question of any influence upon Newton in his independent rediscovery of the series.

The astounding facts are, according to *prima facie* evidence and the latest bibliographic research : (i) *Yuktibhasa* is by an author whose period is 1500–1600 A.D., (ii) the series of Gregory and Newton were first formulated by Madhava, a Kerala Brahmin whose period is *c.* 1350–1400 A.D. A first step towards the establishment of (ii) was the article by himself and Rangachari written in 1878 which turned out to be the last published work of his. He was advised by the Cambridge mathematical historian Dr D. T. Whiteside, to whom this work was submitted before publication, to prepare a monograph updating his findings. He, however, preferred to complete this monograph in the form of research papers. With this plan, he and the author prepared another article highlighting the contents of a palm leaf MS. which they noticed recently in the Adyar Library and which agreed in all respects with Whish's account (*loc. cit.*). This was again submitted to Dr Whiteside whose valuable and frank report was received only on the day of Rajagopal's passing away. This article needs to be improved mathematically, following the suggestions of Dr Whiteside, and to be published.

Honours

Rajagopal was a life member of the Indian Mathematical Society and a member of the London Mathematical Society. He was an elected Fellow of the Indian Academy of Sciences (Bangalore) and of the Indian National Science Academy. He was President of the Allahabad Mathematical Society founded by his good friend,, the late B. N. Prasad. Rajagopal served the Indian Mathematical Society as its honorary Librarian for over 15 years. He, however, declined to be President for even one term, though persuaded by his friends in the Council of the Society. On the other hand, he presided over the mathematical section of the Indian Science Congress in 1963. His presidential address remains a carefully drawn and valuable survey of work in summability methods in India up till then.

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*Ibid., **III,** 1969, p. 34, Footnote (5) : ... *We may forgive him for not knowing that a century and half before, the Hindu mathematician Nilakantha had derived the inverse-tangent series by a 'reductio per divisionem', exactly as James Gregory and Leibniz were to do in January* 1671 *and late* 1673 *respectively : no hint of this reached Europe, it would appear, till* 1835, (*see* A. R. A. Iyer's and R. Tampuran's edition of the 1639 Malayalam compendium *Yuktibhasa,* Trichur, 1948 : 113 ff.; also C. T. Rajagopal and T. V. V. Aiyer, 'On the Hindu proof of Gregory's Series' and 'A Hindu Approximation toπ *Scripta Math.,* **17,** 1951 : 65–74; **18,** 1952 : 25–30; and K. M. Marar and C. T. Rajagopal, 'On the Hindu Quadrature of the Circle, *J. Bombay Branch R. asiat. Soc.*,**20,** 1944 : 65–82). Both Gregory and Leibniz, of course, drew their inspiration from Mercator's quadrature of the hyperbola (*see* H. W. Turnbull's *Gregory Tercentenary Memorial Volume,* London, 1939 : 173, 537; and J. E. Hofmann's *Entwicklungsgeschichte der Leibnizschen Mathematik wahrend des Aufenthaltes* in Paris (1672–1676), Munich, 1949 : 32–36).

Personal Attributes

Rajagopal was a teacher par excellence at any level, graduate, post-graduate or advanced. His teaching was marked by very detailed treatment of the topic, be it either real or complex analysis or statics or dynamics; it did not only adhere to the main text prescribed for the topic but covered additional ground throwing light on the teacher's original study of the topic. Thus he catered very well to the average students while inspiring the bright ones towards original work. Among the students of the latter class should be mentioned : P. Kesava Menon, M. Parthasarathy, T. V. Lakshminarasimhan. As with his teacher, his way with research workers was to encourage and expect them to formulate their own problems and then to discuss the problems wih them.

The author cannot forget the day when he was advised by Rajagopal to work on summability methods revising his own earlier suggestion to work in the theory of groups. It was the day when the author could generalize Rajagopal's results relating to Nörlund summability. On the other hand, he was a very good collaborator who never distinguished his own contribution in a joint work from that of the others. Quite a few who were dedicated workers in other fields and who lacked support in their initial career were encouraged by CTR. One such, Professor K. Ramachandra, while unveiling the portrait of CTR in the Ramanujan Institute could not suppress his emotion when he remembered the encouragement given to him by CTR.

In the present day world of changing fashions in work in mathematics, Rajagopal never swerved from the principle of his revered teacher Ananda Rau, viz. to work in themes dear to us without caring for fads and fashions and to leave the assessment of the work to posterity. In this context, it is appropriate to quote from his Presidential Address to the Mathematics section of the Indian Science Congress, 1963 : As it has been said of old :

"There be of them, that have left a name
to declare their praises, behind them,
And some there be, which had no memorial,
Who are perished, as though they had not been;

but the fact of their having toiled in good faith shall remain continually "a good inheritance" to such as "follow in their foot steps..". Whenever we heard of mathematics in India it always meant the work of one or two, work certified to be superexcellent if not a creation of genius. We should be perfectly certain that mathematics in the country as a whole was a decaying activity. But if we hear of the patient efforts of a host of humble workers to keep alive the spirit of inquiry in mathematics, at different levels and in different directions, persistent efforts in the face of difficulties and discouragements, then we know that the country still is mathematically active. Rajagopal wrote well; whether it was his mathematical papers, or his articles on christianity or psychic studies or reviews or notices, he was very careful in the choice of idiom and of precise expression. Each one of the many letters he wrote to the author is a piece of literature. With no reservations

he used to express his admiration for the work and ideas of his compatriots like B. N. Prasad, V. Ganapathy Iyer, S. Minakshisundaram, V. Ramaswami.

Rajagopal was a believer in rational thinking. He did not take interest in religious rituals, but at the same time did not discourage others believing in them. During India's freedom struggle he demonstrated his nationalism by always wearing Khadi in response to the call of Mahatma Gandhi. About philosophy, unlike his friend Vijayaraghavan, he felt that every one should have his own philosophy. Vijayaraghavan's personal discussions with him about *Visishtadvaita* Philosophy and the Tamil songs of the Vaishnavite saints did not impress him. He more recently used to tell the author that he wished Vijayaraghavan were alive to discuss these matters with the author. On the other hand, Rajagopal believed in the scientific investigation of the so called supernormal and superhuman phenomena. He was quite proud of his views in this aspect, viz., what goes by the name of psychic research, and more particularly in the rebirth of the soul, and was happy that Srinivasa Ramanujan and Ananda Rau too had the same belief. This is more than evident from what he writes in his notice on Ananda Rau. The author vividly remembers Rajagopal quoting from a western work and the former immediately pointing out that, his quotation is a free translation of the sloka

यं यं वापि स्मरन्भावं त्यजत्यंते कलेबरं ।
तं तमेवैति कौंतेय सदा तदाव भावित: ॥

[8–6]

from the *Bhagavadgita.* As one who had immense faith in the knowledge of the Indian seers and saints, Rajagopal remarked that it was but natural that these ideas were found in our own scriptures. Rajagopal had a valuable collection of literature pertaining to psychic research. His lighter reading material was high class detective stories.

Rajagopal was an exemplary gentleman. Nobody, knowing him closely has ever seen him raising his voice. If he ever became angry, it was always in defence of his colleagues and students. The Rajagopals were highly hospitable. The author and some of his colleagues cannot forget the long hours spent at their home. There was always a stream of visitors to their house in Tambaram where each one of the visitors was personally welcomed and treated by Rajagopal and his gracious wife Rukmini. He is survived by his wife and their only son C. R. Srinivasan for whom he showed lot of concern during his last days.

Epilogue

In the interest of scientists and scholars of all times, the author is constrained to end this notice with a saddening note. It is true that India did not offer facilities or congenial companionship to Srinivasa Ramanujan who found them only in England. But having known this truth, authorities in India do not seem to have any intention to learn a lesson from the folly of their predecessors. The authorities of the University of Madras ruled soon after Rajagopal's retirement

that he was not eligible for any pension. He was not considered for an Emeritus Professorship either. He had thus to work on research projects to get financial assistance after retirement. With the intervention of eminent scientists like S. Chandrasekhar and A. Weil (*see* the notice by them in *Nature*, **279,** No. 5711, p. 358 May 24, 1979) an ex-gratia allowance was given to him for a few months till his death. His wife, however, was denied this allowance thereafter, even partially, even after she requested help. The blind and inflexible rule became handy for the authorities to deny her the help. Again, it is the same two eminent scientists, who are obviously high humanists too, who show concern to such souls. The author wishes that the governmental machinery in India and the scientific community in the country shows interest in such matters. It is hightime that a scheme or relief fund is instituted by the government or the Science Academy to help scientists or their families after retirement or death. The author wishes to conclude with fervent hopes that there would be a favourable response to this call.

M. S. RANGACHARI

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JAMSHEDJI JIJIBHOY CHINOY

(1909–1978)

Elected F.N.I. 1974

CHINOY ERA would be the right name and not an exaggeration for the period 1935–78 in Indian Plant Physiology. It was Jamshedji Jijibhoy Chinoy who nurtured, dominated, guided and brought up with a loving care 'Plant Physiology' to the scientific horizon of India. The efforts he put in were tremendous, the difficulties he faced were titanic but what he achieved was a magnificent success and the service he rendered to the discipline will never be forgotten.

EARLY LIFE AND EDUCATION

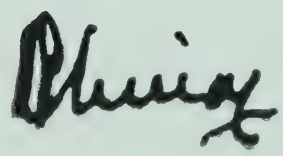
Jamshedji Jijibhoy, the eldest son of Shri Jijibhoy Dadabhoy Chinoy and Smt Gulbanu J. Chinoy, was born on February 18, 1909 at Bhuj (Kutch) in Gujarat. His father died when young Jamshed was only four years old. His maternal grandfather, Pallonji B. Bhagaria, who took care of the child was responsible in many ways in moulding him in his formative years. Chinoy had a happy childhood till the age of twelve when his maternal grandfather died. He had his primary education at Alfred High School in Bhuj from 1915 to 1920 where he matriculated in 1925. His University education was financed by Lady Navazbai Ratan Tata, a great name in the Parsi Community in Bombay. Her magnanimity, humanity and benevolence left a deep impression on young Jamshedji and steered him to a career of teaching and research in science.

His post-graduate studies were done in the University of Bombay, where he distinguished himself not only as a Plant Physiologist of rare ability but also as an all round sportsman, winning many medals and shields as a swimmer, boxer, canoeist and cricket and tennis player. In 1932, he was awarded a Foreign Research Fellowship by the University of Bombay for higher studies in Britain. He worked under the guidance of Professor F. G. Gregory, an internationally reputed Plant Physiologist, at the Biological Laboratories of the Imperial College of Science and Technology, London, and obtained his Ph.D. degree in 1935 and the Diploma of the Imperial College of London (DIC) the same year.

RESEARCH CAREER

On his return to India, Chinoy spent some time in large-scale field experiments on dry land cultivation of wheat at the Godrej farm, Nasik, before his appointment





in 1936 as research assistant in the Agriculture College at Lyallpur, Punjab in a project on "Partial failure of American Cotton in the Panjab" financed by the Indian Central Cotton Committee. He was appointed in 1941 as Assistant Economic Botanist in the newly started Section of Plant Physiology in the Economic Botany Division at the Indian Agricultural Research Institute, New Delhi. From 1947 to 1959, he worked as Reader in the Botany Department of the Delhi University. He joined the Gujarat University at Ahmedabad in 1959 as Professor and Head of the Botany Department. He also worked as Director of the University School of Sciences from 1962 to 1975. Although he retired from active service in 1975, he continued as Professor Emeritus under the UGC sponsorship for two years till his death on May 12, 1978.

Throughout his forty-two year research career, Chinoy was deeply interested in both pure and applied research in Botany. He published more than 200 research papers in journals of national and international repute. His findings on the role of ascorbic acid in plant growth won him international fame. At the Gujarat University, Ahmedabad, he helped establish a strong school of Plant Physiology and many students worked for their doctorate degree under his guidance.

Chinoy worked on a wide variety of research topics in plant physiology.

Correlations between Growth, Metabolism, Development and Crop Yield

Chinoy and his coworkers collected data on a large number of varieties of wheat, oat, barley, linseed, gram, rye, wheat-rye hybrid (triticale) and other crop plants grown at different places in the country. They studied the major growth and yield characters of these plants such as rate of photosynthesis and respiration, height, tiller production, number of leaves, fresh and dry weights of stem, leaf, ear and root, number of ears, spikelets and grains, length of ear, weight of grain and correlated them with the length of the growth period. Also, under widely varying environmental conditions, the relationships between developmental processes, growth and yield were confirmed by subsequent experiments. The important conclusion from these researches was that most of the characteristics of different varieties were correlated with their developmental processes. Major physiological processes of a plant were closely integrated and interdependent phenomena, each of which affected the others markedly. The work of Chinoy established that the rates of production and utilization of regulatory substances were different in different varieties and these differences were linked with the development of the plant, which is either accelerated or retarded by changes in the environmental conditions.

Energy Requirement of Crop Plants

Chinoy, while working on correlations between growth and time of flowering of wheat varieties, observed that alterations in the rate of developmental process changed the growth pattern of the plant. He noticed that the photoperiodic responses of different varieties of wheat were correlated with the length of the

growth period, thus suggesting a quantitative relationship between the amount of energy utilized by the plant and some of its major physiological processes. This was particularly evident in experiments with graded series of photoperiodic treatments given by placing the plants either in continuous light or in reduced photoperiod for 5, 10, 15, 20, 25, 30, 35 and 40 days besides growing them in normal conditions of light. Attempts were made to determine the amount of energy required by different varieties of wheat belonging to different flowering classes during their growth periods, when subjected to vernalization and photoperiodic treatments. Total number of light hours (Photo-quantum-*P*) as well as the sum of degrees of mean diurnal temperatures (Thermic quantum-*T*) of growth period (number of days from the date of germination or transplantation to the date of anthesis) were calculated for plants under different treatment combinations. The products of photo- and thermic-quanta of all varieties under different light and vernalization treatments were found to agree closely for a variety of plant under different treatments. This product was named *Photothermic quantum* of a variety. The difference between the photothermic quanta of unvernalized and vernalized plants of a variety was designated *Vernalization quantum.*

The quantitative relationship between the photothermic quantum, vernalization quantum and length of growth period of wheat had an important bearing upon physio-ecological and physio-genetical problems. The photothermic quantum (E) of a variety is the product of the photo-quantum (P) and its thermic quantum (T). The photo-quantum of a variety in its turn is a product of the mean diurnal photoperiod (P) and its growth period (F); while the thermic quantum is the product of the mean daily temperature (t) and the growth period of the variety. It therefore followed that :

$$E = PT = ptF^2 \quad \text{and} \quad \therefore F = \sqrt{E/pt}.$$

It would appear from the foregoing that if the photothermic quantum of a variety is known, the approximate length of the growth period can be worked out for any given environment from the above formula by knowing the daily mean temperature and the mean day length during its growing season.

Physiology of Inheritance and Selection of High-Yielding Varieties on the Basis of Flowering Time

Chinoy on the basis of these studies of correlations and energy requirements of plants, studied the inheritance of growth and developmental characters by making crosses between different varieties of crop plants belonging to different classes of flowering. Parental and hybrid generations of these crosses were studied by growing them not only under the normal environment of Delhi but also under different photoperiodic and vernalization treatments.

An important result that has emerged from this work is that the segregation of a growth character takes place differently not only in the F_2 plants of different crosses between varieties belonging to different classes of flowering but also in F_2 plants of one and the same cross under different photoperiodic and vernalization treatments.

Chinoy thus, concluded that hybrid plants show the same correlations between growth and development as differently flowering crop varieties and that their response to the change in environment is also similar.

On the basis of these investigations, a new concept of heredity was put forward by Chinoy. It was postulated by him that heredity was controlled by its potential in the cell which he designated as *'Heredity Quantum.'* It was further postulated that it consists of (*i*) a structural complex—'Nucleon'; (*ii*) the energy receptor complex—Energon'; and (*iii*) a developmental complex—'Metabolan.' Nucleon, composed of macromolecules with a vast reactive (adsorptive) surface, served as a template for the synthesis of DNA and RNA which in turn served as templates for proteins, enzyme proteins as well as primary products of nucleon-like ascorbic acid of the organism. 'Energon' was postulated by him to be the potential power of heredity quantum to harness external energy into the pyrophosphate bands of ATP. The rate of production of ATP would depend upon the rate at which photothermic energy is made available to the plant and its photosensitivity.

The 'metabolan' of the heredity quantum represents the potentiality of a plant for energy utilization, resulting in metabolic activity which manifests itself in visible growth and development. The energy of ATP pyrophosphate bands was thought to depend upon the utilization of ascorbic acid as an electron donor. It also depended on the maintenance of a reductive environment so vital for the syntheses of nucleic acids, enzyme proteins, high polymers of carbohydrates and molecules of moderate size. These complexes interact with one another during hybridization.

Chinoy concluded that energy requirements varied in different wheat varieties. An early variety having greater photo-sensitivity could complete its developmental process early, thereby utilizing its resources for early production of flowers, fruits and seeds. Consequently, tiller and leaf production as also the leaf dry-weight was reduced. A late variety, on the contrary, requiring comparatively more photothermic energy, has longer vegetative growth, resulting in larger number of leaves and tillers and greater leaf dry-weight.

Later, Chinoy studied the correlation between yield kernel weight and mean maximum temperature of the ripening period. The results led to methods of selecting wheat varieties which escaped drought as well as damage due to black rust.

Classification of Wheat Varieties on the Basis of Their Energy Requirement

Chinoy felt that an integrated system of classification could be based on correlations between physiological processes like growth, development, nutrition and regulatory mechanisms of plants belonging to different varieties, species, genera and families in relation to their energy requirements for these processes. On the basis of studies of these correlations, an integrated system of classification of different varieties in terms of their energy requirements was evolved. For instance, N. P. 165 was written as *Triticum aestiyum,* 4.31 (0.24); and variety vaneum yakub as *Triticum vavilovianum* 17.91 (2.75), where the figure outside the parenthesis stands for photothermic quantum of the variety and the figure inside the paren-

thesis as its vernalization quantum. From these constants, the vegetative period of a variety was calculated by the formula $F = \sqrt{E/pt}$ in any environment.

Physiology of Drought Resistance

The problem of evaluating drought resistance of a plant which is conditioned by several internal and external factors, is a difficult one. Attempts were made to measure the degree of resistance in terms of one single morphological (seed coat permeability) or one physiological (changes in enzymatic processes and water requirement index) property.

Chinoy carried out physiological studies of drought resistance for 33 years. His work from 1941 to 1977 at the Indian Agricultural Research Institute, New Delhi and subsequently at the Delhi University upto 1959, as well as at the Gujarat University from 1960 to 1974 was basically on the following lines : (*a*) study of a collection of wheats grown on irrigated and 'dry' land; (*b*) determination of varietal resistance to wilting at different stages of growth and development; (*c*) determination of varietal resistance to wilting after synchronization of growth and developmental stages by means of vernalization and photoperiodic treatments; (*d*) presowing hardening treatment of seeds with a view to determining its agrobiological value for Indian conditions; and (*e*) study of protoplasmic and other internal factors determining drought resistance.

Drought Intensity Formula

A method of drought intensity determination was developed by Chinoy in 1960 and during 1964–67. The formula

$$I = K\ t/m,$$

where I is the drought intensity, m is per cent soil moisture during the period of wilting, t is temperature during the same period and K the number of days in the wilting season, was put forth by him.

Experiments with wheat varieties belonging to different flowering classes, subjected to various combinations of vernalization and photoperiodic treatments, showed that when a synchronization of growth and development stages in different varieties was brought about either by accelerating or retarding their flowering, the difference in response to wilting of early or late flowering varieties was eliminated to a considerable extent.

These facts led Chinoy to the conclusion that drought resistance in crop plants is inseparably bound with its major growth and developmental processes as well as with the environmental conditions prevalent during the growing period. Consequently, drought resistance could not be considered as a separate unrelated heritable characteristic.

Pre-sowing Hardening Treatment of Seed for inducing Resistance to Drought and Salinity

Chinoy and his coworkers gave extensive trials to the original method of

Henckel and Kolotova (1934) of presowing hardening treatment for inducing resistance to drought and salinity. The important results obtained by them were :

(*i*) Pre-treated plants gained an appreciable advantage over controls in the seedling stages.
(*ii*) Pre-treated seeds were superior to untreated ones in their capacity to extract moisture from the atmosphere.
(*iii*) The hydrolytic activity of amylase was greater in the pre-treated series compared to controls.
(*iv*) There is a sharp fall in the starch content of pre-treated seeds.

Field experiments carried out at different places with pre-treated and control seeds indicated in some cases, an increase of 25 per cent in grain yield per acre.

Correlations between Intensity of Rust Infection and Temperature and its Bearing upon Yield and 1000 *Kernel Weight of Wheat*

Chinoy was interested in physiological approach to the problem of rust resistance in wheat with respect to its growth and yield. He carried out nearly 3,000 determinations of the intensity of rust infection as well as its effect upon yield. The data showed that the yield was not appreciably reduced in early flowering varieties (100–120 days) even under conditions of virulent infection. As the length of vegetative period increased from 100 to 170 days, the mean maximum temperature of ripening period of varieties in different classes rose from 77° to 96°F and the yield as well as 1000 kernel weight progressively fell with the lateness of the variety.

From such physiological studies he concluded that a practical solution of the problem would be in sowing early flowering varieties at the optimum time in the growing season namely, from middle to end of October. Under these conditions flowering takes place early (second half of January) and a greater portion of grain development precedes the onset of rust infection. Also, grain-ripening takes place in a temperature range that is most conducive for grain-filling processes.

Physiology of Flowering

Evidence regarding the universal presence of gibberellins and anthesins in higher plants is not at all conclusive. During the last nineteen years of his research career, Chinoy and his collaborators undertook work on metabolic drifts of regulatory substances, of which the most important was ascorbic acid (AA). The endogenous content of AA reached a high level earlier in early flowering varieties, synchronizing with change in the growing point from the vegetative to the reproductive state. Also it was noticed that a high level was attained earlier when a late flowering variety was made to flower early by vernalization. Chinoy, Singh and Sirohi in 1957 further found that the rate of utilization of AA also increased considerably during the period of reproductive differentiation. Concomitant with high AA content was rise in the contents of nucleic acids, proteins and carbohydrates as also in ATPase activity. On the basis of the above-mentioned work, Chinoy

propounded the 'ascorbic acid-nucleic acid-protein metabolism' concept of flowering as outlined below :

Under thermo- and photo-inductive conditions, production and utilization of AA takes place at an enhanced rate, thus producing a highly activated metabolic state in the shoot apex at the time of floral induction as well as subsequent reproductive differentiation. Increased electron flow augments ATP formation and consequently DNA and RNA are synthesized at faster rates leading to enhanced syntheses of proteins and enzyme-proteins. The above-mentioned activation of metabolism results in quicker laying down of growth centres and cell division and enlargement processes. A profound change in the differentiation pattern is, thus, brought about leading to the formation of reproductive organs. At a certain critical stage, in some cells the synthesis of nuclear constituents gains a precedence over that of cytoplasmic and cell-wall materials and thus, change in the norm of mitosis is brought about leading to meiotic divisions.

Later, not only the confimatory evidence on the increased production and utilization of AA during floral induction had been obtained but also considerable data on bound AA (ascorbigen) content, special peroxidase activity leading to the formation of free-radical of AA and formation of charge transfer complex of AA with macromolecules was obtained from a number of plant species. These substances remained at appreciably higher levels at the time of floral induction and more so during the entire period of reproductive differentiation. The most noteworthy finding relating to AA metabolism of shoot apex was the pronounced ability of AA to form complexes with DNA, proteins and perhaps other organic molecules of moderate size. Chinoy later obtained such complexing of AA with DNA *in vitro*. This led him to visualize the following mechanism underlying floral induction and differentiation.

It was proposed by him that AA undergoes monovalent oxidation in aerobic condition with the help of a special peroxidase and produces a powerful reducing agent, monodehydro-ascorbic acid (MDHA), which being a free radical, serves as an electron donor in the biosynthesis of macromolecules. Photophosphorylation as well as oxidative phosphorylation are also energised by the flow of electrons from MDHA, thus, augmenting the pool. Dehydroascorbic acid (DHA) resulting from the loss of an electron from MDHA is again reduced to AA with the help of reductase.

The further presumption was the nucleoprotein complexes with AA forming a charge transfer complex. The direct flow of electron energy taking place in the charge transfer 'liberates' the activated form of DNA from protein (histone). Further complexing of DNA with AA leads to the overlapping of their electron clouds and consequently exchange of orbitals in the mobile electrons from one to other. This charge transfer further activates DNA breeding free radicals of the nucleotides, which in turn activates the energy trapping and utilizing potential of the genic material.

Thus, the energies of (*i*) the bond, (*ii*) the free radical and (*iii*) the charge transfer complex are utilized for the production of RNA molecules of different types at ever accelerating rates, thus paving the way for increased production of structural proteins and enzyme proteins during the period of reproductive

differentiation. In fact, the onset of meiosis is caused by a change in the rhythm of nuclear and protoplasmic processes participating in energy regulation and consequently in the formation of new cells and growth centres at enormously intensified rates.

Role of Auxin and Gibberellin in the Synthesis of AA

Work in Chinoy's Laboratory for about twenty years, highlighted the importance of AA metabolism in growth and flowering and the role of auxin and gibberellin also became clearer in the light of their catalytic function in the synthesis of AA. It was shown in 1959 that biosynthesis of AA from sucrose was catalysed by indole-3-acetic acid (Chinoy & Nanda, 1959). This hypothesis was further tested in a number of plant materials like coleoptile and root tips of *Triticum aestivum* cv. Arnej 624 and those of *Avena sativa* cv. Victory (Svolaf) as well as dry excised embryos of *Triticum aestivum* cv. Rival (Svalaf) and those of *Arachis hypogea* cv. A.H. 334 by growing them in various concentrations of sucrose and growth regulators like AA, IAA and gibberellin. Although all the three growth regulators promoted growth in the explants, their effect was best felt when sucrose of a higher concentration (1%) was added to the medium. It was clearly seen from the results that the biosynthesis of AA in the explants is catalysed by the addition of IAA as well as gibberellin in the presence of one per cent sucrose. Simultaneously, the utilization of AA is also appreciably increased by the presence of these growth regulators.

He proposed the following steps in the initiation of growth in a germinating embryo or a root or a coleoptile explant : (*a*) AA's presence increases the imbibing of water; (*b*) AA activates the enzymic systems responsible for the mobilization of reserve substances; (*c*) simultaneously auxins released from bound state catalyze the AA synthesis; (*d*) with the emergence of seedling above the soil and chlorophyll synthesis produces further AA; (*e*) in spite of its increased utilization, the reductive atmosphere which is conducive for synthetic processes in plants increases due to the rising concentration of this powerful agent of the redox system. (*f*) AA acts as an electron donor in photosynthetic and oxidative phosphorylations with which the formation of ATP is coupled; and (*g*) it creates a favourable redox balance for the synthesis of nucleic acids, proteins, enzyme-proteins and cell wall constituents, thus enabling the twin processes of cell division and enlargement to proceed at faster rates.

Role of AA in Crop Production

Alongwith the understanding of mechanism of AA's involvement in the plant growth and development, Chinoy also collected a mass of data on the interaction between AA and auxin, exogenous application of AA to the shoot apices of plants, biosynthesis of AA by different organs of plants as well as on the AA content and its utilization during the course of growth period of different crop plants such as *Triticum, Hordeum, Avena, Secale, Triticale, Cicer, Cajanus Arachis, Linum* and others grown under different photoperiodic and vernalization treatments, also point to the important role of AA in growth and development.

On the basis of foregoing evidence, a simple pre-treatment of seed with AA was developed by Chinoy. It was found to accelerate germinative process as well as growth and yield of mature plants.

Method of Pre-Treatment of Seed with AA developed by Chinoy

One mg of seed was taken and soaked in 400gm of cold water in which 10–20mg of AA was dissolved. The seeds were continuously stirred and after they had absorbed all the liquid, they were covered with wet cloth and kept in moist condition for about 6–8 hours, with frequent stirrings at intervals of 10 minutes. The seeds with hard seed coats were kept under moist conditions for longer durations. After the end of wet period, seeds were spread to dry in a cool shady place for 48 hours. The dried seeds may again be put in a fresh solution of AA to repeat the above treatment 2–3 times. As this pretreatment raises the water as well as mineral absorbing capacity of plants, a higher nutritional level in the soil was recommended to be essentially present in order to derive the maximum benefit of seed pre-treatment. This seed pre-treatment was also found to be a protective measure against seed-borne diseases. A number of varieties were tried by Chinoy and the results showed an increase in yield from 7 to 33%.

Honours

Chinoy received recognition from various national and international scientific institutions. He presided over the Plant Physiology Section of the IX International Botanical Congress held at Montreal, Canada in 1963. The X International Botanical Congress at Edinburgh in 1964 called him as a special invitee. He was a visiting scientist at various biological laboratories in Netherlands, England, France and Germany. He was invited by the German Academy of Science to deliver lectures on his research work. Chinoy was called to preside over the meetings of such distinguished gatherings as International Symposia on Arid Zone Problems held at Bhavnagar, 1965; International Seminar on Tissue Culture held at Baroda in 1965; International Seminar on Plant Growth Substances held at Calcutta in 1967 and Physiology of Differentiation in Plants held at Simla in 1971. He was one of the leading scientists invited to participate in the Seminar on 'Cellular and Molecular Aspects of Floral Induction' at Liege, Belgium in 1967. As an Honorary Vice-President of the XII International Botanical Congress at Leningard, USSR in 1975, he was awarded a medal for best research. He was the patron member of the Indian Society for Plant Physiology which he served in the capacities of Secretary, Vice-President and President. His elections as Fellow of the Indian National Science Academy and National Academy of Sciences in 1974 and 1975 respectively were recognitions of his contributions to science. More recently, in 1975 Chinoy got the *Rafi Ahmed Kidwai Award* for research in Agricultural Botany and Plant Physiology.

Personal Life

On November 5, 1938, Chinoy was married to Roda, daughter of Shri Rustam D. Khambata. She helped him in great measure in his research career and her

support, understanding, inspiration and encouragement went a long way in raising him to distinction. The Chinoys were blessed with three sons and two daughters. While one of his sons, Major N. J. Chinoy, has a record of thirteen years service in the Indian Armed Forces, his elder daughter Dr (Miss) Niloufer J. Chinoy adopted a research career and is a Reader in Zoology at the Gujarat University. Unfortunately, one of his sons died at the young age of 32 in 1977 and this was a great blow to him.

Chinoy was a devoted husband and father who adored his family. He was an avid gardener. He inculcated in his children a love for nature at a very early age. The atmosphere at his home was happy, congenial and conducive for the attainment of high academic pursuits.

An Inspiring Personality

He was an inspiring personality, a noble and compassionate person who always lent a helping hand to the poor and needy. The greatest contribution which he made to science was to inspire young minds and mould them in the pursuit of science. He left a lasting impression on the minds of his students, who felt the fulfilment of the saying 'one lamp lights another, nor grows less, so nobleness enkindleth nobleness.' His motto was "Work is worship" and very often he used to quote :—

"*Honour and shame for no condition arise*;
Act well thy part and therein all the honour lies."

Undoubtedly, Chinoy lived upto that dictum.

K. K. Nanda
Rajiv Kumar Sharma

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J Venkateswarlu

JILLELLA VENKATESWARLU

(1912-1978)

Elected F.N.I. 1961

JILLELLA VENKATESWARLU was born in an orthodox Hindu family on March 21, 1912 at Komaragiripatnam, East Godavari District of Andhra Pradesh to the worthy parents, Srimathi Lakshmi Devi and Sri Ramamurty.

EDUCATION

During his childhood, the family moved to Kakinada, a town in the same district, where Venkateswarlu had, almost all his education, from primary school to college. Throughout, he stood first in his class and was awarded prizes and merit scholarships. As a student, he was modest and essentially shy but never lacked the courage to face difficult situations. His father, himself a teacher, was particular that Venkateswarlu should take up a learned profession. So, after his B.Sc. with Botany as main, and Zoology and Chemistry as subsidiaries, he pursued his M.Sc. (Botany) at the Banaras Hindu University, Varanasi. Pandit Madan Mohan Malaviya, then the Vice-Chancellor of Banaras Hindu University, was impressed with his merit and gave him a scholarship. He again secured first rank in his batch.

During his undergraduate courses, he came under the influence of Sri Goparaju Ramachandra Rao (GORA), an illustrious teacher who later became a renowned social reformer, Dr U. Lakshmana Rao, Sri T. U. Chacko, and in the post-graduate courses, of Professor A. C. Joshi and Professor Y. Bharadwaja. Soon after passing his M.Sc. examination in 1934, he was made a member of the teaching staff of the Botany Department of the Banaras Hindu University, where the foundations for his research career were laid under the inspiring guidance of Professor A. C. Joshi. Later, he came into contact with Professor P. Maheshwari, who was impressed by his ability and made him a close friend and encouraged him throughout.

PROFESSIONAL CAREER

In 1937, he was appointed Lecturer in Botany at the Andhra University, Waltair, to teach Pharmacognosy. He was specially selected by Dr C. R. Reddi, the well-known educationist and Vice-Chancellor of the Andhra University, when Pharmacy courses were started. There, he came in contact with Professors S. Bhagavantam and T. R. Seshadri who encouraged him to continue his researches, and the Andhra University provided him special facilities.

With the opening of the Erskine College of Natural Sciences in 1942, he taught all aspects of Botany first to the B.Sc. (Hons.) Geology students and later to the B.Sc. (Hons.) and Post-graduate students of Botany. The D.Sc. degree was awarded to him in 1946 and he was promoted to the post of Reader in Botany. Impressed by the high appreciation of his D.Sc. thesis by the three foreign examiners, Dr C. R. Reddi and the Syndicate of the Andhra University deputed him to the University of Cambridge, England, for specializing in Cytogenetics. There, inspired by his research guide, Professor D. G. Catcheside, he conducted elegant researches on chromosome behaviour in autotetraploid maize, and also on the understanding of the embryological phenomena in *Oenothera blandina* De Vries, a deficiency-duplication heterozygote. While at Cambridge, he came into contact with Professor R. A. Fischer, the outstanding mathematical geneticist, who put into his mind for first time the need for a statistical approach to cytogenetic problems. On his return from Cambridge with a Ph.D. in Cytogenetics in 1951, he was elevated to Professorship and was appointed as Head of the Department of Botany to succeed the earlier distinguished personalities, Professors M. O. P. Iyengar and G. N. Rangaswamy Ayyangar. With his knowledge and research experience in several areas of Botany, he became an asset to the University.

He was the chief architect in building up the Botany Department of the Andhra University as a leading centre in India with a good reputation not only for high quality of training imparted to students but also for excellence of research carried out under his leadership. He guided researches in plant embryology in the beginning and later concentrated on plant cytogenetics particularly on crop plants. He was also interested in Vegetative Anatomy, Floristics, Plant Physiology and encouraged research in Aerobiology, Plant Pathology, Marine Algae, Wood Anatomy and such other areas that promoted multidisciplinary work in plant sciences. He successfully developed the Department into a well-integrated unit of all aspects of Botany.

Contributions

His main contributions lie in the field of Plant Embryology and Plant Cytogenetics In Plant Embryology, he was the first to describe the cell lineages in Embryogeny. He applied the systems of the famous French botanists, Souges and Crete, and the American botanist Johannsen on the large order Myrtales which resulted in a great deal of significant research in Systematic Embryology of Angiosperms in our country. In cytogenetics, he and his students were the first to map the pachytene chromosomes of several crop plants like Sorghum, Pearl millet, Job's tears, Solanums, Tomatillo, Mustards, Brassicas and several fodder grasses. This work is of considerable significance both for understanding the genome relationships and for its potentiality in application to crop improvement. His studies on the dynamics of chromosome behaviour in the autotetraploid maize, worked out in Cambridge, and later extended to other crops by him and his students, were both unique and difficult. In recognition of this work, the University Grants Commission sanctioned a Special Assistance Centre in

Cytogenetics for the Department of Botany under his leadership. He was looked upon as an outstanding authority on Plant Cytogenetics in the country and was specially known for his skill in developing methodologies and for his interpretative abilities. Professor Catcheside expressed his opinion about him as one who *"has a great deal of skill in his science, a real love of his work and an extraordinary degree of appreciation and devotion to essential detail."* His studies of the infrequent embryological events on genetically marked strains of Maize and *Coix* covering haploidy, heterofertilization and apomixis, were an attempt to bring about an alliance between Embryology and Genetics, a field which is difficult as well as necessary. He worked with great determination ignoring several lucrative offers from other institutions. He contributed much to the growth and development of Botany not only in the Andhra University, but in Andhra Pradesh as a whole.

Thirty students took their M.Sc. (by research) degrees, three their D.Sc. degrees and nineteen their Ph.D. degrees under his supervision. Many of them have occupied or are holding positions of distinction in India and abroad.

At the Andhra University, his rise was phenomenal. He was a member of the Academic Council and Senate throughout; Principal, Colleges of Science and Technology (1968–71); Member of the Syndicate (1970–73) and was elected Chairman, Faculty of Science (1969–72). He discharged his duties ably in all these capacities without allowing them to interfere with his teaching and research.

He retired as Professor and Head of the Department of Botany, in 1972. In recognition of his meritorious service, the University appointed him as Emeritus Professor, a position he held till his last day. The Indian Council of Agricultural Research, appointed him as Emeritus Scientist (1972–75), and the University Grants Commission as Research Scientist (1975–78). He kept himself active till the very end.

Honours

During his eventful career as a scientist and teacher for over 40 years, many were the awards, honours and distinctions conferred on him. The Indian Botanical Society awarded him *Birbal Sahni Memorial Gold Medal* (1971) and the Indian National Science Academy, the *Bashambarnath Chopra Lecture Award,* 1974. The Government of Andhra Pradesh honoured him as one of the eminent scientists during the World Telugu Conference held at Hyderabad (1975). He attended the VII International Botanical Congress at Stockholm and Upsaala, Sweden (1950). He was a Fulbright Fellow and Visiting Professor at the Department of Genetics, University of Wisconsin, Madison, U.S.A. (1963–64) under the Indo-U.S. Educational and Cultural Exchange Programme. Here, he was actively associated with the paramutation work in maize in collaboration with Professor R. A. Brink. He also visited several Institutions in U.S.A. and came into contact with distinguished scientists like Professor M. M. Rhoades, Professor P. C. Mangelsdorf, Professor E. B. Lewis, Professor L. F. Randolph, Professor G. W. Beadle and others. Under the Indo-Soviet Cultural Exchange Programme,

he toured Soviet Russia in 1967 giving lectures at various Universities, Institutes of Genetics, Academies of Agriculture on Crop Plants and held discussions with Academicians like Professor Dubinin, Professor Loboso and others. He participated as an invited delegate in the Binational Conference for Education and Research in Life Sciences held at Bangalore (1971) under the auspices of the National Council for Science Education of India, University Grants Commission and United States National Science Foundation. He chaired many national and international symposia and participated in an Indo-Soviet Symposium on Plant Embryology in 1977 held at Leningrad, U.S.S.R.

He was connected with many Scientific bodies and Institutions. He was Secretary (1956–61), President (1962), Vice-President (1963) and Treasurer and Business Manager (1966–72) of the Indian Botanical Society with head-quarters at Waltair; President, Botany Section (1962) of the 49th Indian Science Congress; President, Indian Society of Genetics and Plant Breeding (1966); Founder-President (1966, 1967) and Vice-President (1971), Indian Society of Cytology and Genetics; Elected Fellow (1961), Indian National Science Academy and Member of its Council for 3 years (1966–68); Elected Fellow (1952), Indian Academy of Sciences; Fellow (1963), Indian Botanical Society; Fellow (1956), Indian Society of Genetics and Plant Breeding; Foundation Fellow and Vice-President (1971–74), Andhra Pradesh Academy of Sciences; Convener and Secretary of the Sectional Committee No. VI (Botany, Applied Botany etc.), Indian National Science Academy; Member of the Basic Research Committee (Exploration), Indian National Science Academy; Member, Council of Andhra Pradesh Academy of Sciences; Member, Central Advisory Board of Biology, Government of India; Member, University Grants Commission Expert Committee; Member, Panel of Scientists, University Grants Commission; Member, Advisory Committee, Botanical Survey of India; Member, Executive Council, National Botanic Gardens, Lucknow; Member, Botany Committee, Indian Council of Agricultural Research; Member, Editorial Boards of several Scientific Journals; and Member, Boards of Studies of several Universities.

Personal Virtues

Inspite of his high stature and busy schedule, he was always available to his students and colleagues for academic discussions. Always courteous and dignified, he was soft spoken, but when necessary very outspoken also even if he knew that such open expressions could affect his personal career. Both young and old sought his advice and this was always given with careful consideration of pros and cons. He was a modest and warm individual with a score of students, colleagues, friends and admirers, all over the world. His friendship transcended beyond the plant science community and many eminent personalities in various walks of life, were his good and close friends. He was sympathetic to meritorious poor students and often helped with their college fees, remembering his own hardships during his college days. He displayed as much concern for his students as he did for members of his own family.

Family

He was married in 1936, to Srimathi Manikyamba, a simple and affectionate lady from a Zamindari family, and had three sons. The eldest is a Chemical Engineer, the second a Medical Doctor and the last a student of Philosophy.

Death

After a life full of events, he died suddenly on May 20, 1978 at the Waltair railway station, soon after detraining, due to a massive heart attack, before any medical assistance could be given. In his death, the botanical community of India lost a great savant and the Andhra University a dedicated scientist. The Department of Botany, whose present position is largely due to the labours of Professor Venkateswarlu, remains a glorious tribute to the memory of his selfless service and ambition. He will be remembered not only for his scholarship but also for his deep sense of humanism.

Rolla S. Rao
Panuganti N. Rao

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BOOKS, MONOGRAPHS AND TECHNICAL BULLETINS

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LAKSHMINARAYANAPURAM ANANTHAKRISHNAIYER RAMDAS

(1900-1979)

Elected F.N.I. 1935

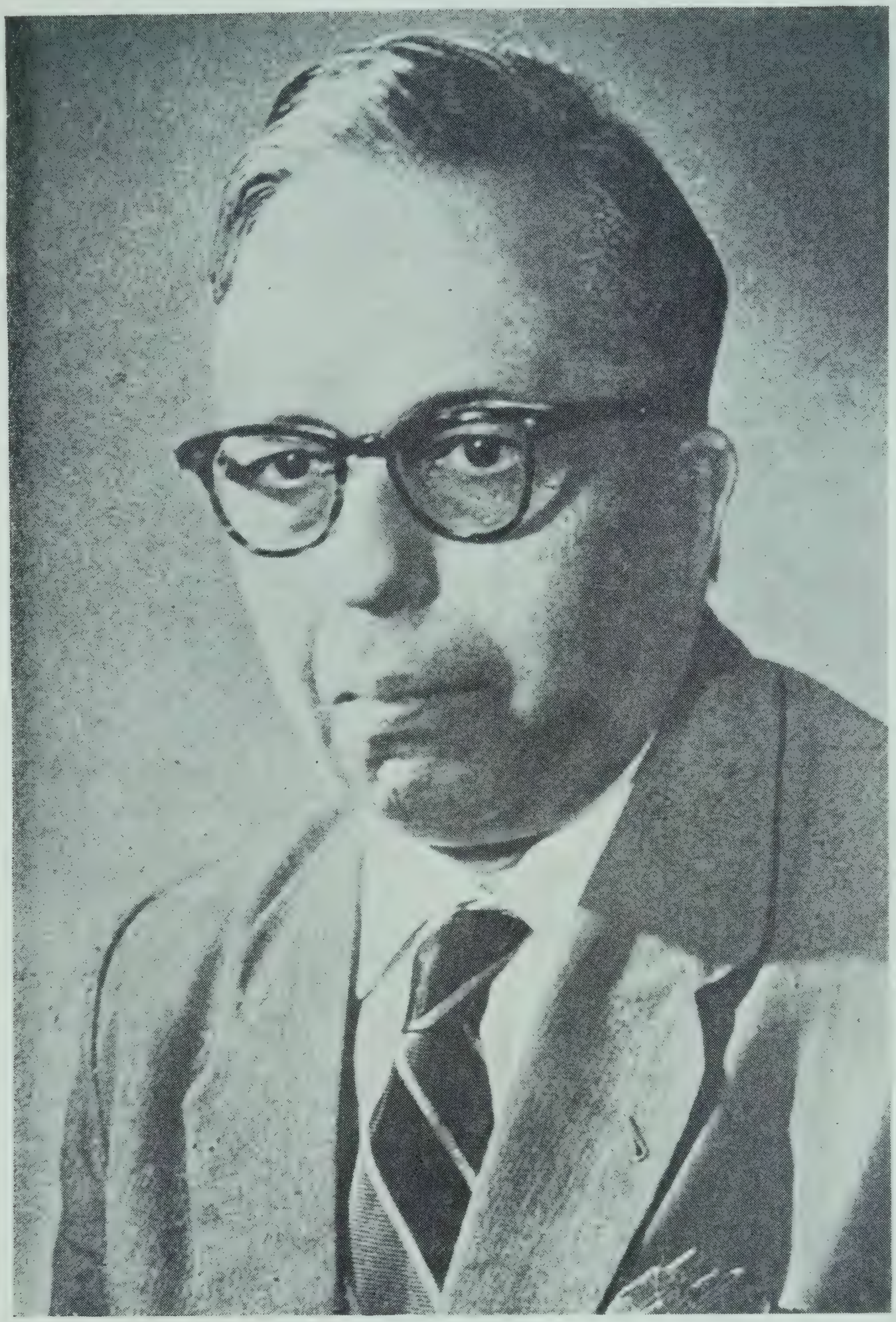
LAKSHMINARAYANAPURAM ANANTHAKRISHNAIYER RAMDAS, the pioneer of modern Agricultural Meteorology in India was born in a Brahmin family in Palghat in the Kerala State on June 3, 1900. His father, Professor L. K. Ananthakrishna Iyer was a renowned anthropologist and an ethnologist who made penetrating studies of the Tribes and Castes of Kerala and Mysore.

EDUCATION & RESEARCH

Ramdas took his B.A. degree from the Presidency College, Madras in 1920. The following year, he went to Calcutta where his father was Professor of Anthropology in the University. Their residence was close to that of Professor C. V. Raman and just behind 210, Bowbazar Street, the then headquarters of the Indian Association for the Cultivation of Science. Under the inspiring guidance of Professor Raman, the Indian Association had become an active centre of Research in many branches of Physics and attracted research workers from different parts of India. Professor Raman was also the Palit Professor of Physics in the University College, Calcutta, where he gave regular courses of lectures to post-graduate students working for their M.Sc. and Ph.D. degrees.

Ramdas along with his friend K. S. Krishnan regularly attended these lectures, moved about in the Association, meeting the scientists working in the Laboratory and became familiar with the problems on which they were working. Ramdas took the M.A. degree of the Calcutta University in 1923, and shortly after, obtained a Palit scholarship to work in the Association laboratory.

While his friends, K. S. Krishnan and S. Venkateswaran were working on problems of the volume scattering of light by various liquids and vapours, Professor Raman asked Ramdas to turn his attention to the study of the surface scattering of light by liquids and solids. A large number of liquids like water, organic liquids, mercury and liquid carbon dioxide at different temperatures and pressures were studied The scattering of light by the liquid surfaces was explained as being due to molecular bombardment of the surfaces by the overlying molecules of air or vapour. The results of these studies were published in 1925 in a series of three papers by the Royal Society, London, by Professor Raman and



R A Ramdas

Ramdas, on "The scattering of light by liquid boundaries and its relation to surface tension" These and other allied studies gained for Ramdas the Ph.D. degree of the Calcutta University in 1927.

Professional Career & Contributions

In 1926, Ramdas joined the India Meteorological Department as an Assistant Meteorologist and was posted to the Meteorological Office, Karachi, where he gained experience in the growing field of Aviation Meteorology.

In 1930, Dr Ramdas was transferred to the Poona Meteorological Office. Besides doing his regular duties, Ramdas found the environment congenial for starting work on the physical problems of ground-atmosphere interface. In collaboration with S. L. Malurkar and S. Atmanathan, he made measurements on the changes occurring in the temperature and moisture content of air layers close to the ground, upto a height of about 10ft, from early morning to late afternoon hours. They discovered that just above the heated land there were narrow jets of rising hot air alternating with broader areas of descending cold air.

In 1931, on the initiative of the Imperial Council of Agricultural Research (ICAR), a Research Section on Agricultural Meteorology was created in the Meteorological Office, Poona, to study "Weather in relation to Crops" and Dr Ramdas was appointed Meteorologist-in-charge of the Section. Funds for starting and maintenance of the Agricultural Meteorology Section were provided by ICAR.

With the co-operation of the authorities of the Poona Agricultural College, plans were made for setting up an Agri-Met Observatory on the grounds of the College. The College authorities provided 1/4 acre in the middle of their farm area for the observatory. Starting with a few basic meteorological instruments, new equipment was acquired or built and installed, and regular observations were started and systematically analysed. The college authorities, the India Meteorological Department and ICAR, took keen interest in the work. It was arranged that *annual reports* of the work of the Section be sent to ICAR, who reviewed the work and communicated the results to the Agricultural Organisations in different parts of the country.

The Agri-Met Section started with a staff of 12 including 3 scientists with Dr Ramdas as Director, and 6 scientific assistants and observers. In 1940, a Planning Branch was added with a staff of 13 members for building up liaison activities with agricultural farms and for organizing a "Weather Service for the Farmer." Between 1945 and 1947, the staff was increased by another 26 to work the fully planned "Co-ordinated Crop-Weather Scheme" of ICAR. The work done by the staff and students of the Agricultural Meteorology Section between 1932 and 1948 was summarised in the following two publications by Dr Ramdas:

1. The progress of Agricultural Meteorology in India during 1932–48; and
2. Dr Ramdas's Presidential Address to the Physics Section of the Indian Science Congress—Patna 1948. "The Physics of the bottom layers of the Atmosphere."

During this period, 158 original papers and 47 reports were published by the staff and research students of the Agricultural Meteorology Section. The scientific papers were on the following topics :—

(i) Meteorology—General.
(ii) Micro-Meteorology and related topics. Development of Instruments.
(iii) Radiation : Solar radiation, radiation from night sky, nocturnal cooling, frost, etc.
(iv) Physics and particularly soil physics; including soil temperature, moisture, movement of salts, soil swelling, etc.
(v) Problems of Plant Physiology in relation to meteorological factors.
(vi) Statistical : Crop-Weather Relationships and Analysis of meteorological data having a bearing on the principal crops grown in different parts of the country.

In 1948, the ICAR made the following comments on the work done by the Agricultural Meteorology Section : "*The Committee was highly impressed with the high quality of the work conducted, and particularly wanted to place on record its high appreciation of the work done by Dr Ramdas, Director for evolving and organising the Scheme* (*Co-ordinated Crop-Weather Scheme*). *It was a matter of particular gratification for India that the Indian Crop-Weather Scheme as approved by ICAR has been adopted by the International Commission of Agricultural Meteorology at its meeting held in Toronto in August-September,* 1947."

It may be mentioned that in 1946, Dr Ramdas was awarded M.B.E. by the Government of India (British). The Co-ordinated Crop-Weather Scheme was taken over by the India Meteorological Department of the Government of India on a permanent basis in April 1949.

From 1948 onwards, Dr Ramdas and his collaborators in the Agricultural Meteorology Section continued to work on the Hydrology of arid and semi-arid tracts of India like Rajasthan and parts of Peninsular India, on convective phenomena over heated surfaces, on solar and wind energy in India, on evaporation from lakes and ponds and their control, and general problems of meteorology and micro-meteorology. In 1953, Dr Ramdas became Deputy Director-General of Observatories (Climatology and Geophysics). He retired from the India Meteorological Department in 1956.

In December of the same year (1956), Dr Ramdas joined the National Physical Laboratory as Assistant Director, in-charge of Heat and Power Division, and continued in that capacity till 1960–61. His active interest in problems of Weather and Crops, Control of Evaporation, Solar Terrestrial Radiations, Thermal balance at the earth's surface etc. continued.

Dr Ramdas was appointed Member of the UNESCO Advisory Committee for Arid Zone Research in 1958. He attended and took part in the annual meetings of the Committee which were held at Teheran (1958), Madrid (1959), Paris (1960), Rome (1961), Tashkent (1971), and Jodhpur (1972). He was able to arrange for UNESCO Aid to the Desert Research Institute at Jodhpur.

Honours

In 1958, the President of India honoured L. A. Ramdas with a *Padma Shri.* In 1965, the President, CSIR, appointed Ramdas as "Emeritus Scientist" with freedom to work in the National Physical Laboratory. He occupied a room in one of the upper levels of the tower of the Laboratory and continued to make laboratory studies on Thermal repulsion properties of various types of soils etc.

Foreign Visits and Other Distinctions

The following is a brief summary of Dr L. A. Ramdas's visits abroad to attend International Scientific Conference and Special Meetings.

1951	Brussels	IUGG Assembly.
1953	Paris	WHO Commission on Agricultural Meteorology.
1954	Perth	Pan-Indian Ocean Science Congress.
1956	Canberra	UNESCO Symposium on Climatology and Micro-Meteorology.
1957	Bangkok	Pacific Science Congress : Dr Ramdas suggested the term Bio-Meteorology which has a broader significance than *Agricultural Meteorology.*
1961	Rome	U. N Conference on New Energy Sources.
1964	Leningrad	International Radiation Conference organised by IUGG and WMO.
1966	Lebanon	International Bio-Meteorology Conference.
1968	Bergen	Symposium on Radiation (IUGG and WMO)

In the autumn of 1960, Dr Ramdas was invited as a Foreign Visiting Scientist under the joint programme of the National Science Foundation of USA and the American Meteorological Society. He delivered courses of lectures on the Environmental Problems (on which he and his collaborators had worked) at a number of Universities and other Scientific Institutions and held discussions with the Faculty members and Research Scholars. The lectures and discussions were greatly appreciated.

In 1961, Dr Ramdas was invited to participate in a "Ten Year Planning Conference on the Atmospheric Sciences" held at Boston under the Chairmanship of Dr Sverre Petterssen. The Conference lasted six weeks—man's ability to control the atmospheric circulation and atmospheric phenomena came in for special attention. The plans evolved for the ten-year programme envisaged an outlay of 500 million U. S. Dollars.

The scientific academies and societies in India and abroad of which Dr L. A. Ramdas was a Fellow or Member are enlisted below :—

1.	Indian Academy of Sciences, Bangalore	Foundation Fellow	1935
2.	Indian National Science Academy, Delhi	Fellow	1935

3.	National Academy of Sciences, Allahabad	Fellow	1948
4.	Indian Meteorological Society	Fellow	1948
5.	Royal Meteorological Society, London	Fellow	1936
6.	American Meteorological Society	Professional Member	1961
7.	World Academy of Arts and Sciences	Fellow	1963
8.	Indian Geophysical Union	Fellow	1967

Death

Dr Ramdas's health began to fail in the last few months of 1978 and he passed away peacefully on the afternoon of January 1, 1979, leaving his wife, two sons and three daughters.

Acknowledgement

The author wishes to express his thanks to Dr A. R. Verma, Director of National Physical Laboratory, New Delhi, for giving information about Dr Ramdas's work in National Physical Laboratory during 1956–60 as an Assistant Director, and later as Emeritus Scientist during 1965–70. Thanks are also due to Dr L. A. Ramdas's son Professor A. K. Ramdas, who supplied him copies of notes which Dr Ramdas himself had kept of his life and work.

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Bonaccini

BISHNUPADA MUKERJI

(1903–1979)

Elected F.N.I. 1943

BISHNUPADA MUKERJI was a well-known pharmacologist of India. He was a great organiser, an erudite scholar, a prolific writer and an eloquent speaker. His unfailing amiability and graciousness endeared him to all who came in contact with him.

BIRTH, CHILDHOOD, SCHOOL AND UNIVERSITY EDUCATION

Mukerji was born on March 1, 1903 in an orthodox Brahmin family at Barrackpore, 24 Parganas, close to Calcutta. His father, Upendra Nath Mukerji, was an Administrative Assistant of the then Eastern Bengal Railway, and his grandfather was Vice-Principal of the Sanskrit College, Calcutta. His mother, Hemantakumari, was noted for her piety. They had five children; Bishnupada was the third.

From his early days, Bishnupada showed great promise. He had his early education in the Shyambazar Vidyasagar School where he passed the Matriculation Examination of the Calcutta University in 1919 with distinctions in Sanskrit, Bengali and Mathematics and was recipient of a Government scholarship and a gold medal. He then joined the Intermediate in Science course of two years of the Calcutta University at the Scottish Church College, Calcutta, and passed the final examination, with distinctions in mathematics, physics and chemistry and won the *Fyfe Scholarship* of the College.

With a good foundation in basic sciences, Mukerji opted for the Bachelor of Medicine course of six years at the Calcutta Medical College. He had a Government scholarship throughout this period and completed the course with Honours in Pharmacology, Obstetrics and Gynaecology in 1927, stood first in order of merit and won a number of gold and silver medals.

PROFESSIONAL CAREER

At the Calcutta Medical College, he came in close touch with the pioneer pharmacologist of the country, Col. Sir Ram Nath Chopra, Professor of Pharmacology at the famous Calcutta School of Tropical Medicine, situated at the northwest corner of the Calcutta Medical College campus. During 1927–28, he worked as Resident House Surgeon at the Eden Hospital of the Department of

Obstetrics and Gynaecology of the Calcutta Medical College. Here he impressed his teacher, Professor Greenarmitage, Head of the Department who had his assistance in his private practice. Soon after completion of his term as house surgeon, Mukerji joined the research team under R. N. Chopra in the Pharmacology Department of the Calcutta School of Tropical Medicine as an Assistant under the Indigenous Drugs Inquiry of the India Research Fund Association, now known as the Indian Council of Medical Research. This was the beginning of his research career as a pharmacologist.

During 1930–31, he was deputed as Assistant Secretary to the Drugs Enquiry Committee of the Government of India, New Delhi. In this position, he had the opportunity to travel around and acquire first hand information about the drugs situation prevailing in different parts of the country. Practical knowledge of different aspects of drugs and pharmaceuticals and their related problems, acquired by him at that early stage of his professional career, was well utilised by him during the rest of his active life in the development of the Pharmacopoeia of India, the Indian Pharmaceutical Codex and the newly started drug control system of the country.

He resumed research at the Calcutta School of Tropical Medicine in April 1931 and continued to work on some well-reputed indigenous drugs of the country e.g. species of Artemesia, Squills, Chenopodium, Ipecacuanha and *Makaradhwaja.* Two of his earliest papers with Chopra were on 'Value of the antimony test in the diagnosis of *Kala-azar*, Part II—the Finger Prick Blood Test' published in April, 1930, in the *Indian Medical Gazette*, **65,** and 'Narcotine, its pharmacological action and therapeutic uses' published in July 1930, in the *Indian Journal of Medical Research*, **18.** After these two, several papers followed with Chopra, mainly in these two journals. The most notable contribution during this period was a paper entitled 'Pharmacological action of an alkaloid obtained from *Rauwolfia serpentina* Benth.' by R. N. Chopra, J. C. Gupta and B. Mukerji. This important paper published in 1933 initiated the inclusion of extracts and alkaloids of *R. serpentina* in modern therapy, especially in hypertension and in insanity, throughout the world. A decade later, J. C. Gupta and B. S. Kahali published their interesting paper on the highly potent character of *Rauwolfia oleoresin* fraction, which used to be discarded during isolation of the total alkaloids of *R. serpentina.* This important finding led to the isolation of the natural tranquilliser, reserpine, an alkaloid with rather weak basic properties, by J. M. Mueller, E. Schlittler and H. J. Bein at Basle, Switzerland in 1952. Another important paper of Chopra and Mukerji was "Pharmacological action of 'thevetin' ", a glucoside occurring in *Thevetia nerifolia* (yellow oleander) in view of the cardiac activity of its active principle.

Considerable amounts of the alkaloid, narcotine, were being obtained in those days at the U. P. Government Opium Factory, Ghazipur, as a useless byproduct. Work on pharmacological action of narcotine was carried out by Mukerji with the object of finding a suitable use for the product. His work with Chopra on 'Pharmacological action and antimalarial properties of anhydrocotarnine-resorcinol hydrochloride (a derivative of narcotine)' was published in 1933.

In 1933, he was awarded a fellowship by the Rockefeller Foundation. For three

years it enabled him to carry out pharmacological researches in a number of countries, though for most of the period he worked in the laboratory of Professor Edmunds, Chief of the Department of Pharmacology, Michigan University, Ann Arbor, Michigan. He obtained his D.Sc. degree from this University in 1936 on the basis of his dissertation, 'The effect of certain therapeutic agents on thiocyanate metabolism in cyanide poisoning.' Subsequently, he worked in China and it resulted in the paper on 'Effect of pressor principle of the anterior lobe of the pituitary body on the liver-fat after the feeding of choline chloride' published in the *Chinese Journal of Physiology* in 1935.

On his return to India early in 1937, Dr Mukerji was appointed Pharmacologist at the newly started Biochemical Standardisation Laboratory of the Government of India at the Calcutta Medical College campus with Col. Chopra as its Director. The laboratory was charged with the important and responsible function of control and maintenance of standards in drugs and pharmaceuticals for use in the country. In 1941, after retirement of Col. Chopra, Dr Mukerji took charge of the Laboratory as Officiating Director. After independence in 1947, this Laboratory was named Central Drugs Laboratory and Dr Mukerji was appointed as its first Director. He also held charge of the Pharmacognosy Laboratory of the Government of India at the campus of the Indian Museum in Calcutta.

He ably managed the affairs of the Central Drugs Laboratory and developed it enormously starting from practically a scratch, in spite of all the difficulties he had to face at the formative stage, while he had his office room at the All-India Institute of Hygiene and Public Health, across the street to the Calcutta Medical College campus. As the Laboratory was situated in those days at the Calcutta Medical College campus and as he was continuing his researches during the period and was also vigorously working as the General Secretary of the Indian Science Congress Association, it was quite a strenuous job for him to manage with all these. He did the spade work for having the building at Kyd Street for the Central Drugs Laboratory. He also did the spade work for having the Science Congress building, which was built by Dr U. P. Basu, F.N.I., his successor as the General Secretary of the Indian Science Congress Association. The building stands on Dilkhusa Street, presently known as Bires Chandra Guha Street.

During this period, he was actively engaged in his researches, mostly on standardisation of drugs. Mention may be made in this connection about his work on dextrorotatory hydrocupreidine derivatives, effect of anterior pituitary extracts on smooth muscles under influence of some amines related to ephedrine, effect of sodium nitrate and methylene blue on thiocyanate formation in cyanide poisoning, method of determination of prothrombin time, medicinal value of *Alstonia scholaris* and *Caesalpinia bonducella,* antimony content and toxicity of Urea stibamine, assay of Indian ergot, physiologically active fractions of Indian hemp, assay of individual sclerotium of ergot, cantharidin content of *M. macilenta* beetles, protein hydrolysates, assay of insulin, quality of peptone for bacteriological work, snake venom as a therapeutic agent, unsaponifiable matter in shark-liver oil, prolongation of insulin effect by combining with casein hydrolysate, assay of globin-insulin preparations, biological standardisation of liver extracts by pigeon

method, assay of histamine content of tissue extracts using antihistaminic drugs, microbiological assay of vitamin B_{12}.

About the middle of July 1951, he took over charge of the newly started Central Drug Research Institute at Lucknow as its first permanent Director. This Institute is one of the National Laboratories under the Council of Scientific and Industrial Research. The famous Chattar Manzil Palace of Lucknow was fitted up as the Research Institute. This was quite a difficult task, but Dr Mukerji proved himself well up to the mark and immediately after his joining there he took up this task in all earnestness and pursued the programme of development of the Institute vigorously so that within seven months of his joining there, he could organise an International Symposium on the very interesting subject of "The recent progress in Hormone Research and the use of Hormones in Therapeutics" in February, 1952 This was practically the first symposium of its kind in this country and is one of the best so far held from the standpoint of general standard, objective approach, realistic presentation of the related information/problems, and seriousness of purpose in scanning all the various aspects of the particular area. It was indeed a great feat on his part and for this he had to work hard during the few months available to him. At the time of the symposium, the large number of delegates, who gathered from different parts of the country and from abroad, were highly satisfied to see a well-organised, multidisciplined, and progressive biomedical research Institute running smoothly as if the Institute were established a long time ago.

During the valuable twelve years he was at the helm of this Institute, most of his time was occupied in planning and management of research and further development of the Institute. This helped enormously the rapid growth and expansion of the Institute along right lines. However, he was still keenly interested in continuing his research activities. Among his research contributions during the period, mention may be made of pharmacological action of alkaloids of *Cissampelos pareira,* a method of isolation of dendritic cell from human and guinea-pig skin, evidence against corticotropin-like action of melanophore hormone on adrenal cortex of mice, studies on experimental atherosclerosis, studies on experimental diabetes, studies on experimental tuberculosis, studies on leucoderma including treatment, experimental peptic ulceration, action of *makaradhwaja* (Ayurvedic mercuric sulphide preparation).

With his keen sense about capabilities and prospective qualities of growing young scientists, he soon collected around him at the Institute a large band of very promising young scientists. As a result of the serious and well-disciplined activity of this band of research workers, the Institute soon became well recognised in the country and abroad as a progressive centre for biomedical research. By the time he retired from the Institute in 1963, all its different divisions had grown enormously and were throbbing with activity.

Particular mention may be made of his keen interest in looking after proper growth of the scientists working at the Institute and this special consideration towards them enabled him not only to have from them maximum help and cooperation for furtherance of the cause of development of the Institute but also to see them become competent for higher responsibilities. It is significant to note

in this connection that both the succeeding Directors of the Institute since his retirement and the first two Directors of the Industrial Toxicology Research Centre at Lucknow under the Council of Scientific and Industrial Research, as also the first Director of the Cholera Research Centre at Calcutta, under the Indian Council of Medical Research earlier worked in his team at the Institute for very long periods.

After his retirement from the Institute, he joined the Chittaranjan National Cancer Research Centre in under the Ministry of Health, Government of India Calcutta as its first wholetime Director in April 1963 and worked for five years upto 1968. Even during these last five years of his service life, he maintained his vigorous organisational activity and brought about immense improvement and expansion of this Centre and opened a Cancer Chemotherapy Field Research Centre at Chandernagore.

Shortly after completion of his term at the Chittaranjan National Cancer Research Centre towards the end of 1968, Dr Mukerji was in difficulty with regard to his health for a considerable of long period. In April, 1970, under a University Fellowship Programme, he started on a trip round the world as a Visiting Lecturer and attended a number of international conferences. On his return in 1971, he became associated with the Department of Biochemistry of the University of Calcutta as Honorary Visiting Scientist. Later, he was on a temporary assignment as a Consultant on Reproductive Biology at the Calcutta Office of the Ford Foundation. The writer fondly remembers his impressions regarding Dr Mukerji at work at his office during the last phase of his active career. He strictly maintained his regularity and sense of responsibility in discharging his duties, his objective approach and seriousness of purpose admirably well even during this period.

Organisational Activity

B. Mukerji will be remembered as a great organiser amongst the scientists of the country keeping in view the prevailing environmental conditions and the resources available to him. In this respect, his efforts were equally successful in development of drug testing laboratories of high standard, institutes for researches on drugs and diseases, scientific societies, etc. In the first instance, he gave a practical shape to the newly started Biochemical Standardisation Laboratory in Calcutta under the Ministry of Health, Government of India and ultimately developed it into the Central Drugs Laboratory of the present day as its first Director. Today, it is an organisation of great national importance.

The most important evidence of his organisational activity is provided by the development of the newly started Central Drug Research Institute at Lucknow as its first permanent Director. It grew up, during his time, into a very big research institute and in a short time became well known throughout the world as a great centre for researches on drugs and diseases. As its first wholetime Director, with his valuable organisational experience in development of multidisciplined institute for biomedical research, he developed the Chittaranjan National Cancer Research Centre during the five years he was there.

The Indian Science Congress Association became a very important organisation after independence of the country in 1947. As the General Secretary of this Association during the five-year term, 1947–52, he worked not only hard but also efficiently for conducting the activities of this Association in the right direction and meeting the challenges the situation demanded. He was very eager to construct a building for this Association and through his initiative and efforts and later through his successor as the General Secretary, Dr U. P. Basu, it was possible to have the building where the Association is at present functioning smoothly. He was a founder member of a number of scientific societies. Mention may be made about his efforts for the establishment of the Indian Brain Research Association, Indian Association for the Biological Sciences and the Indian Biophysical Society.

Mukerji's chief contribution is with regard to the development of the *Indian Pharmacopoeia*. He also worked hard for the publication of the *Indian Pharmaceutical Codex*. In fact, he had initiation in this field at a very tender age in 1930, i.e., within three years of his graduation in medicine, when he was deputed as Assistant Secretary to the Drugs Enquiry Committee. Since then, he was all the time very intimately associated with developments in this area resulting in development of huge drugs and pharmaceuticals industry in the country.

Of particular mention is his high standard of knowledge in chemistry. It may be recalled that in his early college days he was highly accomplished in physics, chemistry and mathematics. His proficiency at the initial stage in the natural sciences in addition to his spcialisation in medicine was of immense help to him in organising and conducting the activities of the multidisciplinary biomedical research institutes. His keen interest in chemistry may be evident from the fact that though a medical man he was a Fellow of the Indian Chemical Society and a Foundation Fellow of the Institution of Chemists (India). He was President of the latter body for the two years, 1972–73. His *H. K. Sen Memorial Lecture* of this body for 1963 on 'Indian Drug Industry—past, present and future' is a valuable document in this field based on his long experiences in research, standardisation and control of drugs, development of the *Indian Pharmacopoeia* and his intimate contacts with the developing drug industry of the country at the different stages, *vis-a-vis* his knowledge about up-to-date developments in this area in the world acquired through his contacts, visits and critical studies.

Honours and Awards

He was elected a Fellow of the Indian National Science Academy in 1943, and was a member of the Council of this body during 1947–65, 1967–68 and 1974–75. He served this Academy as a Vice-President in 1954–55 and 1962 and as the Foreign Secretary in 1957–60 and 1967–68. He was the President of the Physiology Section of the Indian Science Congress in 1945, its Acting General Secretary in 1946–47, its General Secretary during 1947–52 and the General President of the Congress in 1960–61. He was a member/fellow of a very large number of scientific societies in India and abroad. He was the President of the Asiatic Society in 1972–75, the Indian Pharmaceutical Association in 1959–60, the Indian Pharmaceutical Congress Association in 1960–61, the Physiological Society of

India, the Institution of Chemists (India) in 1971–72, the Indian Science News Association in 1972. Amongst his membership of foreign scientific societies, mention may be made of American Society of Pharmacology and Experimental Therapeutics, American Pharmaceutical Association, Sigma Xi, American Association for Advancement of Science, New York Academy of Sciences, American Society of Pharmacognosy, British Pharmacological Society, Pharmaceutical Society of Great Britain, Deutsche Pharmakologische Gesellschaft, La Societe Helvetique des Sciences Naturelles, etc., and an Honorary Member of the Egyptian Pharmaceutical Association.

He was awarded a large number of medals and prizes. Mention in this respect may be made of the following : *Griffith Memorial Prize* for 1938, *Nilmony Brahmachari Medal* for 1938, *Asutosh Mookerjee Medal* for 1940 and *Coates Medal* for 1941 of the University of Calcutta; *Indian Science Congress Medal* for 1951 and *Barclay Medal* for 1954 of the Asiatic Society; *Squibb International Award* for 1962; *H. K. Sen Memorial Medal* for 1963 of the Institution of Chemists (India); *Acharya P. C. Ray Medal* for 1975 of the Indian Pharmaceutical Association; *Shree Dhanwantari Prize* for 1976 of the Indian National Science Academy. His services towards development of scientific research in the biomedical field was duly recognised by the President of India by the award of *Padma Shri* to him in 1962.

Family Life and Last Days

On November 18, 1933, just a few days prior to his departure for U.S.A. for higher studies and research, he married Susama, daughter of Benoy Krishna Banerjee, Principal, D.A.V. Art College, Lahore, and Lakshimoni. He had a very peaceful and happy family life. Dr Mukerji was highly sociable by nature and in this respect Mrs Mukerji was always by his side. She was of immense help to him, and a great source of inspiration in his varied activities. For twelve years at the Central Drug Research Institute, Lucknow, they were residing at the Institute campus and this environment was very much helpful to them for developing friendly personal relations with practically all the members of the staff. In later years, when the writer had opportunities to visit the Institute and stay at the attached Guest House, on numerous occasions he heard from old members of the staff, even of the very junior categories, how they loved and held in high esteem Dr and Mrs Mukerji.

Amongst their two sons and one daughter, the eldest son, Mr Debangshu Mukerji is working with the Metal Box Co. Ltd., Calcutta and the other son, Dr Sudhangshu Mukerji is a scientist working at the Indian Drugs and Pharmaceuticals Ltd., Hrishikesh. Their daughter, Miss Sucheta Mukerji, is a scholar in English, at present working at Loreto College, Calcutta.

Throughout his life, Dr Mukerji was very methodical and regular in his habits, very prompt in attending to his letters and correspondence. He used to rise up early in the morning and worked throughout the day without recess. A good part of the day he used to read and write. His total number of publications may be well around four hundred including the review articles and special informative scientific articles. Only the more important ones are listed under 'Bibliography'. He was very

regular in attending meetings and liked to take active part at such meetings. As he was intimately connected with numerous organisations and was a member of a large number of Committees, Commissions, Delegations, etc. attendance at such meetings was a regular part of his daily programme throughout his active life extending up to his last day. He never felt tired even after return from his rather frequent trips to foreign countries.

During his last few years, he was not keeping well. Though he was not negligent to his health and was taking all possible measures for recovery, he was carrying out his usual duties more or less normally up to practically the last day without giving any chance to any of his numerous friends and colleagues to know that he was not keeping well.

The end came on July 30, 1979 with his wife, two sons and his daughter by his bedside along with a host of his friends, admirers and relations. His passing away was deeply mourned by a very large number of individuals and oraganisations throughout the country and abroad.

R. N. CHAKRAVARTI

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